POWER PLANT ENGINEERING

Established Over 33 Years

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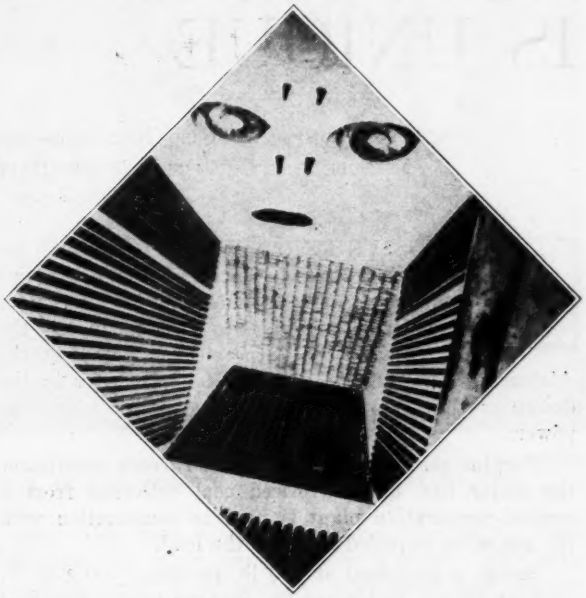

Furnace Fanny

WHO ELSE but our titian haired goddess of the boiler room incognito? A little cockeyed perhaps, King Tut beard a little awry, nevertheless the fickle little red-hot lady herself.

And those eyes—such eyes! A glance from them melts—nay! nay! Not hearts, but bricks! Strong men shudder and turn away and women faint when they behold the destruction those fiery orbs accomplish and the depths of despair to which they drive her followers.

After all, it is both awe inspiring and discouraging to see nice, neat, new solidly molded firebrick sink so low as to associate freely with ash and clinker, literally wallowing in the gutter.

This is the first time Fanny has ever been photographed and she did it to help us celebrate a special treat we have prepared for our readers in this issue. The generation and utilization of steam and electric power in nine industries is discussed in nine articles by nine different authors, each a leader in his own field. They begin on page 1276 and extend to page 1303. Fanny consented to her one and only public appearance on condition that she be hostess. If you want to see Fanny herself, we'll let you in on a secret known only to a very few. The method is simple. First get in the condition where you can roll in the gutter without embarrassment, then instead of a gutter pick out the ash hopper of a modern furnace and, lying on your back, look forward. But unless you have a penchant for cremation or feel like cheating the undertaker out of a fee, pick the right furnace at the right time.

Gulf States Steel Co.'s NEW POWER PLANT IS UNIQUE

By H. T. WATTS
Superintendent of Power
Gulf States Steel Company

CROSS COMPOUND TURBO-GENERATORS AND HIGH PRESSURE INDUSTRIAL EVAPORATORS FEATURE PLANT. SURPLUS WASTE HEAT POWER SOLD TO PUBLIC UTILITY COMPANY

EXTENSIVE EXPANSION in progress at the Gulf States Steel Co. during the past two years necessarily included the installation of a modern power plant to meet adequately the increased demand for electric power at the Alabama City, Alabama works. Many features in the design are novel, particularly in the field of industrial power.

Surplus gas from one 500-t. blast furnace constitutes the major fuel but pulverized coal delivered from a central preparation plant is used in combination with the gas when required to carry the load.

Steam is produced at 400 lb. pressure, 700 deg. F. on four 900-hp. boilers, of the Stirling type. The steel encased boilers are equipped with air-cooled walls and air preheaters. Combustion air is drawn through the hollow walls by the forced draft fan and then forced through the air preheater and to the gas and coal burners.

Referring to the cross section of the plant, it may be seen that fuels enter in conformity with rather general practice for combination firing. The gas burner discharges a correct mixture of gas and air at the rear, this first passing under a long inclined suspended arch, thence under the high-set mud-drum to the large combustion chamber. Sufficient length of travel is provided under the arch to permit complete combustion to take place before the flame is allowed directly to radiate heat to the tube surface. This construction is of particular advantage in the combustion of fuel gases of low calorific value, such as furnace gas, which contains not more than 100 B.t.u. per cu. ft. The two pulverized coal burners are located one above the other in the front wall, because, in this position, there is ample opportunity for direct radiation from the flame to the tubes as required with fuels producing such high flame temperatures as pulverized coal.

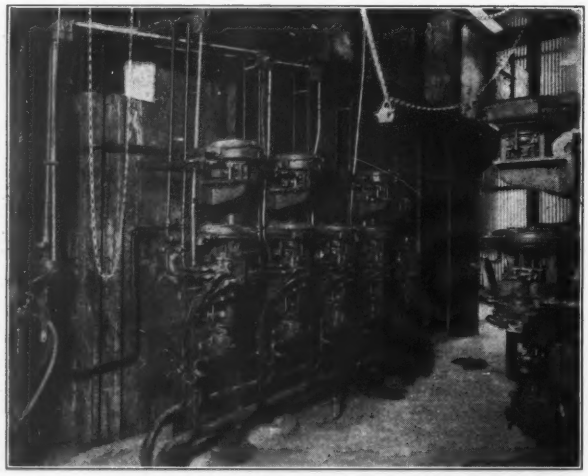

FIG. 1. COMBUSTION CONTROL EQUIPMENT ON ONE BOILER

SEPARATE COAL PREPARATION PLANT PREPARES PULVERIZED COAL

Coal unloaded into the track hopper is transported by skip hoist to the top of the building where it enters the crusher. Two crushed coal bins below the crusher have a combined capacity of 500 t. Two 10-t. per hr. pulverizers are located on the ground floor. Pulverized coal is entrained in the air circulation through the mill and delivered through cyclone separators and a duplicate system of screw conveyors to individual boiler bins, the latter having a capacity of 20 t. each. No coal dryer is included in the equipment, but when preparing wet coal, hot air from the preheaters can be bled into the air circulation which passes through the pulverizer.

Combustion of fuels is controlled by a complete system of automatic regulation. The two master controllers have distinctly separate functions. One regulates the fuel supply to maintain constant steam pressure, while the other manipulates the quantity of gas supplied to the boilers in such a manner that the pressure in the 72-in. supply main is kept constant. The latter precaution is necessary in order to ensure an adequate supply of gas for use on the hot blast stoves, an integral part of the blast furnace equipment. The coal burners are not put into operation by the regulators but by hand. After these are started, they come under full control of the regulators.

These master regulators, while regulating the quantity of each of the fuels used, also cause to be introduced with the two fuels, the correct amount of air for proper and complete combustion. An additional regu-

FIG. 2. TURBINE ROOM OF THE GULF STATES STEEL CO. THE TWO UNITS IN THE BACKGROUND ARE BLOWERS, THE TWO IN THE FOREGROUND, THE TWO ELEMENTS OF ONE CROSS COMPOUND GENERATING UNIT

lator manipulates the damper position and induced draft fan speed to produce balanced draft conditions as required. With motor-driven fans, it is of course necessary to provide means to ensure safety in case of power interruption. This is accomplished through the use of additional elements attached to the regulators. One attachment shuts off the fuel supply when a predetermined pressure is obtained in the combustion chamber, this condition of course being prevalent in the event of shut-down of the induced draft fan.

Station Auxiliaries All Electric Driven

Another attachment opens butterfly dampers, permitting entrance of air to the gas burners directly from the room in case of shut-down of the forced draft fan. The height of the boiler is such that the available draft without the use of either fan is sufficient for operation approaching 100 per cent rating of the boilers. While making such operation possible, these safety attachments also eliminate the possibility of large quantities of stray fuel escaping into the boiler room when power is interrupted.

All station auxiliaries are driven by electric motors. Heating of the feedwater is accomplished by multi-stage extraction of steam from the prime movers by closed heaters. All condensate is returned to the boilers, and makeup water as required, is supplied through the high pressure evaporator system. High pressure steam from the boilers is supplied only to turbo-blowers, turbo-generators and evaporators. This permits a nominally complete return of the condensate in a completely closed system.

Two steam-driven turbo-blowers are installed, each capable of delivering 60,000 c.f.m. of air at 30 lb. pressure. One unit is ample for operation of the blast furnace, the other being held as a spare. The units are equipped with surface condensers and bleeder heaters, the latter extracting steam by induction, at three points in the expansion, in sufficient amount of heat the unit's own condensate approximately to the saturation temperature corresponding to the pressure of steam at the first bleeder, that is about 350 deg. F.

Demand for steam outside the station necessitated the use of evaporators to produce steam at 150 lb. pressure. This is required for miscellaneous use at the adjacent blast furnace and coke plant. Two evaporators are installed with a capacity of 25,000 lb. per hr. each. Live steam from the high-pressure boilers is supplied to the evaporator coils, the quantity being automatically regulated by means of a constant pressure regulator and balanced valve in the high-pressure steam line to the evaporators. Raw water is first passed through sand filters under service pressure, then delivered to the evaporator shell by means of a multi-stage pump. Solids which collect in the shell are removed by frequent blow-down.

High-Pressure Evaporator Drains Heat Evaporator Feedwater

A heat exchanger is provided in the system to heat the evaporator feedwater, heat being supplied by the hot high-pressure drains from the evaporator coils which pass through the heat exchanger parallel to the feedwater. After passing through the heat-exchanger, the evaporator drains enter the evaporator drain pump, through the agency of which they are pumped into the boiler feedwater line for ultimate re-use as feedwater for the high-pressure boilers. An additional portion of

the evaporator 150-lb. steam is used for station makeup, condensed in a manner described in a later paragraph.

Cross Compound Turbines Unique

Arrangement of the turbo-generators in two compound units is rather unique for a plant of this size. Each compound unit is composed of one 5000-kw. high-pressure machine and one 2500-kw. low-pressure machine, giving a total capacity of all units of 15,000 kw. The low-pressure units were moved from another location in the works where they had previously been served with steam at 3 lb. pressure delivered from reciprocating engines driving rolling mills. With the electrification of these mills, exhaust steam for the turbine units was no longer available, and electrical power was required to drive the new motors which had replaced the engines. It seemed logical that these units be moved to the power house and that high-pressure non-condensing turbines be installed to furnish them with steam at the desired pressure.

Two Elements Operate as One

In reality, the two elements of a compound unit operate as one and it is impossible to operate one of them without the other. The stator windings of the two generator elements are cross-connected. There is no connection to put live steam into the low-pressure unit, nor is there provision for removing steam from the receiver pipe, except by passage through the blading of the low-pressure machine. There is no throttle in the steam line between the two machines.

Both high and low-pressure machines are equipped with speed governors and over-speed trips. The speed governor on the high-pressure machine is controlled by an electric motor operated from the switchboard to vary the speed and load. The over-speed trips on the high and low-pressure machines are each equipped to operate a quick closing valve in the steam line to the high-pressure machine, when overspeeding occurs. On the low-pressure unit the governor is set to act upon the high-pressure unit governor in the event of excessive speed of the low-pressure turbine, and in so reducing the steam supplied to the combination unit, may often make unnecessary and prevent the operation of the over-speed trips, which operation would of course cause complete shut-down of the entire compound unit. Since there is no throttle to control the speed of the low-pressure unit, it is necessary in starting the compound machine to obtain excitation from an outside source, and the units are brought up to speed in synchronism with the fields on.

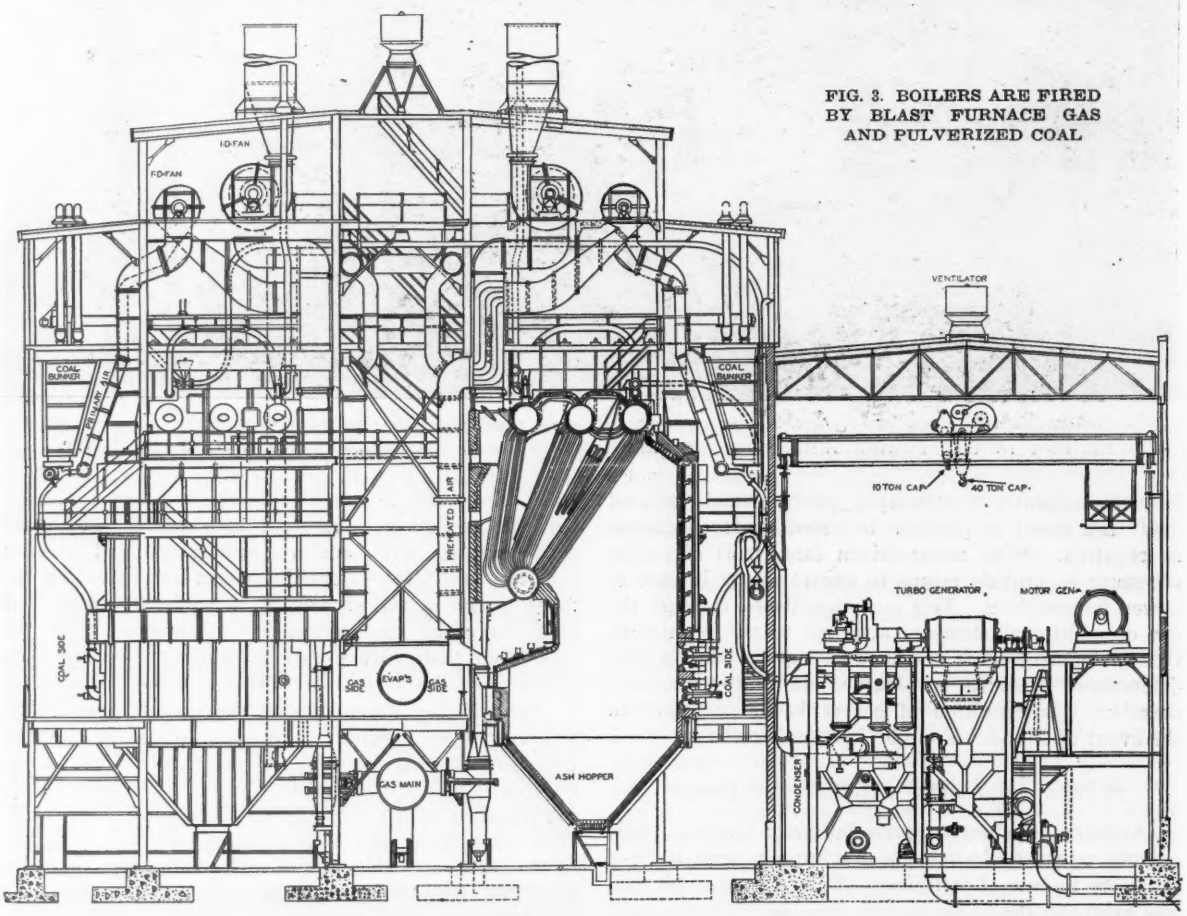

FIG. 3. BOILERS ARE FIRED BY BLAST FURNACE GAS AND PULVERIZED COAL

Three Stage Feedwater Heating Used

For the turbo-generators, as in the case of the blowers, bleeder heaters are supplied for extraction of steam at three points with sufficient heater capacity to heat the turbine condensate to approximately 350 deg. F. It was impractical to bleed steam from the low-

pressure turbine, because the unit was not originally designed with this in view. The low-pressure heater draws steam from the cross-over pipe between the two elements of the compound unit, taking a part of the exhaust from the high-pressure turbine. The high-pressure heater bleeds steam from the turbine at about 125 lb. pressure, while the intermediate heater is located midway between the high and low-pressure heaters in the expansion.

Heater condensate is driven from the high to intermediate, thence to the low-pressure heater by means of successive pressure differences in the respective heater shells. Aggregate heater condensate collected in the low-pressure heater shell is drawn out by a small heater drain pump and discharged into the main condensate system against the head developed by the hot well pump at a point in the system between the low and intermediate heaters.

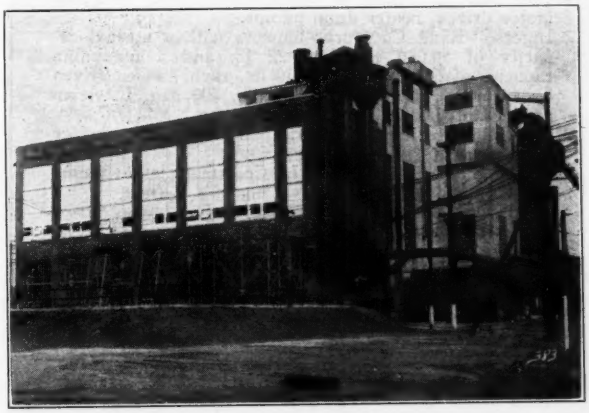

FIG. 4. EXTERIOR OF THE POWER PLANT. COAL PREPARATION HOUSE AT THE FAR RIGHT-HAND CORNER

Precaution against heater tube failure and consequent danger of flooding the turbine casing is accomplished through the use of float operated valves, which act when the water in the heater shell reaches an unusual height. Movement of this external float operates a pilot valve, admitting high-pressure water to pressure cylinders, causing the hot-well pump discharge to bypass around the heater. At the same time, a valve in the line admitting steam to the heater shell is positively closed. By this means, flooding of the turbine casing due to heater tube failure is positively obviated. One such system is provided for each low-pressure heater and one system for each intermediate and high-pressure combination.

Drain Pumps Replaced by Heat Exchanger

Heater arrangement on the blowers is identical with that installed for the generating units, except that no heater drain pumps are used in the former system. The aggregate heater condensate in the low-pressure heater shell on the blower turbine is passed through a small heat exchanger, where it is cooled by the condensate delivered by the hot-well pump, whence it passes to the hot well and again enters the primary circulation.

Generator air is circulated in a closed system and is cooled by the condensate from the hot well pump. This condensate then passes through the turbine oil coolers. Passing from the oil coolers, it enters the steam jet air ejector intercooler and after-condenser, leaving the latter after a temperature rise of 30 deg. F. The main condensate then passes through the low-pressure heater, still under the head developed by the hot-well pump

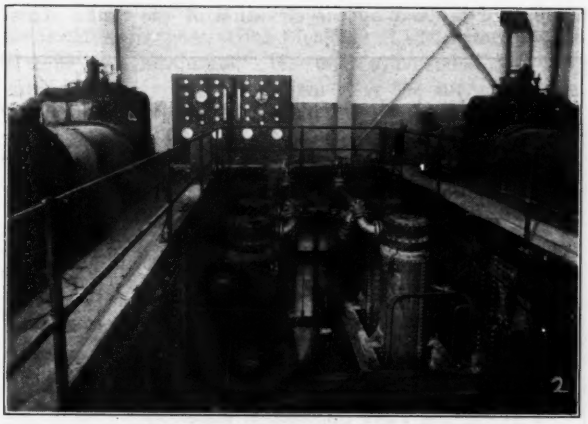

FIG. 5. BLEEDER HEATERS FOR BOTH TURBINES ARE SET SIDE BY SIDE

and still in a separate system carrying only the condensate from one unit.

After passing through the low-pressure heater, the condensate enters a manifold where it joins the condensate from the other turbine, and the two streams enter

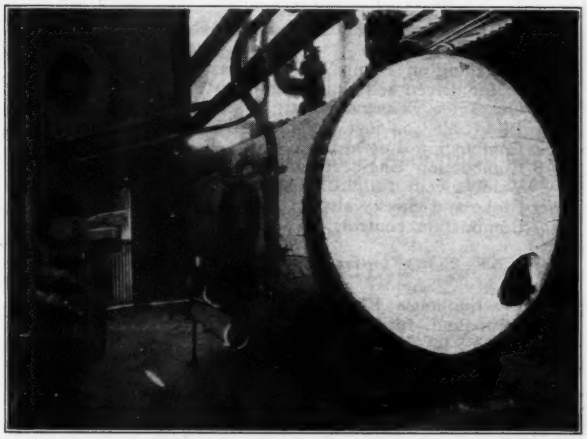

FIG. 6. ONE OF THE EVAPORATORS THAT SUPPLIES 150 LB. PROCESS STEAM

one of two boiler feed pumps. The water is then run in two parallel branches, each directing its portion through an intermediate and high-pressure heater in series. After leaving the heaters, the water enters either the main or auxiliary feed line and is ready for entrance into the boiler through the feedwater regulators. The corresponding system for the turbo-blowers is identical with this, except that only one blower is in service at a given time. Condensate from the high-pressure evaporators is also pumped back into the main or auxiliary feed lines as previously described.

Sudden fluctuation in boiler water levels and abrupt changes in load make it impossible to operate with an

entirely closed condensate and feedwater system. A head tank is installed on the boiler house roof to compensate such irregularities. This tank is connected with a manifold, having a branch to each group of heaters. Connection is made in each case into the main condensate system at a point near its entrance into the low-pressure heater. The pressure at this point is about 50 lb. and is fixed by the elevation of the tank. This determines the pressure against which the condensate pumps operate and the pressure inlet upon the boiler feed pumps.

When the condensate from the condensers is momentarily greater than is required by the boilers, the excess passes through its regular circuit until about to enter the first heater; but at this point, it changes its course and passes up to the head tank. Conversely, when the demand is momentarily greater than the supply, the deficit is drawn from the head tank, and enters the system at the same point, ahead of the first heater.

It is interesting to note that the location of the head tank connection makes it possible to deliver the excess water to the head tank before heating takes place and that the deficit, when drawn into the system from the head tank, enters at a point where it can take advantage of the entire group of heaters. The water level in the head tank is maintained constant through the use of a float regulator which automatically starts and stops the head tank pump. This pump draws water from a large distilled water storage tank located at the ground line. An overflow from the head tank drains into this ground tank as required.

Makeup Supplied from Evaporator System

In the boiler house, the main feedwater line is bypassed through a high heat level condenser. Steam from the evaporators is connected to the condenser shell. When it is found that the distilled water storage tank needs replenishment, the makeup operation is put

Principal Equipment for New Power Plant of the Gulf States Steel Co. at Alabama City, Alabama

BOILER ROOM AND COAL PREPARATION HOUSE

4 Babcock & Wilcox Co., 9068 sq. ft., 400 lb. pressure Stirling boilers.
4 Superheater Co., Elesco superheaters designed for 250 deg. superheat at 300 per cent boiler rating.
4 Vulcan Soot Cleaner Co., 7-element soot blowers.
4 Stets Co., feedwater regulators, normal capacity 60,000 lb. per hr., maximum capacity 75,000 lb. per hr.
4 A. W. Cadman Mfg. Co., blowoff valves.
4 Everlasting Valve Co., blowoff valves.
4 Edward Valve & Mfg. Co., non-return valves.
8 Consolidated Ashcroft Hancock Co., 4½-in. safety valves.
8 Freyn Engineering Co., gas burners.
8 Combustion Engineering Co., pulverized coal burners.
8 Combustion Engineering Co., coal feeders.
4 Combustion Engineering Co., air preheaters.
4 B. F. Sturtevant Co., No. 6½ motor driven induced draft fans.
4 B. F. Sturtevant Co., No. 4½ motor driven forced draft fans.
4 Detrick Co., air cooled walls with steel casings.
4 Detrick Co., suspended arches.
4 Allen-Sherman-Hoff Co., ash hoppers and sluice system.
1 Worthington Pump & Machinery Corp., 1000 g.p.m. motor driven ash sluice pump.
1 Guarantee Construction Co., skip hoist.
1 Link-Belt Co., 60 t. per hr. coal crusher.
2 Combustion Engineering Corp., Raymond 10-t. mills.
6 Combustion Engineering Corp., screw conveyors.
Gate valves.....The Chapman Valve Mfg. Co.
Globe and check valve.....Edward Valve & Mfg. Co.
Combustion controls.....Smoot Engineering Corp.

TURBINE ROOM

2 Westinghouse Electric & Mfg. Co., 6500-kw. cross-compound, turbo generators, each unit consisting of one 385-lb., 700 deg. F., 4000-kw. high-pressure element operating against a back pressure of 3 lb. gage and designed for 3-stage bleeder heaters and one 2500-kw. low-pressure element operating with 3 lb. steam at 28 in. vacuum.
2 Westinghouse Electric & Mfg. Co., 6600-sq. ft. surface condensers.
4 General Electric Co., generator air coolers.
8 Andale Engineering Co. oil coolers.
2 Westinghouse Electric & Mfg. Co., steam jet air pumps.
6 Croll-Reynolds Co., 407-sq. ft. bleeder heaters.
4 Worthington Pump & Machinery Corp., 150-g.p.m. motor driven hot well pumps.
3 Worthington Pump & Machinery Corp., 50-g.p.m. motor driven, heater drain pumps.
2 Ingersoll-Rand Co., turbo-blowers with a normal capacity of 50,000 c.f.m. at 22 lb. and a maximum capacity of 60,000 c.f.m. at 30 lb., each blower driven by a turbine designed for 385 lb., 700 deg. F. steam and designed for 3 stages of extraction.
2 Westinghouse Electric & Mfg. Co., 4800-sq. ft. surface condensers.
2 Westinghouse Electric & Mfg. Co., steam jet air pump.
6 Croll-Reynolds Co., 304-sq. ft. bleeder heaters.
2 Croll-Reynolds Co., 196-sq. ft. heat exchangers.
2 Worthington Pump & Machinery Corp., 125-g.p.m. motor driven hot well pumps.
2 DeLaval Steam Turbine Co., 150-g.p.m. motor driven boiler feed pumps.
2 DeLaval Steam Turbine Co., 400-g.p.m. motor driven boiler feed pumps.

MISCELLANEOUS

3 Westinghouse Electric & Mfg. Co., 10,000-g.p.m. motor-driven circulating pumps.
1 Worthington Pump & Machinery Corp., 15,000-g.p.m. motor-driven reservoir pump.
1 DeLaval Steam Turbine Co., 350-g.p.m. turbine driven emergency boiler feed pump.
1 Westinghouse Electric & Mfg. Co., 7500-g.p.m. dual drive service water pump driven by a Westinghouse motor and a Terry turbine.
2 Hardie-Tynes Mfg. Co., 1050 c.f.m. synchronous motor driven air compressors.
1 Hardie-Tynes Mfg. Co., 254 c.f.m. motor driven belted air compressor.
2 Foster Wheeler Corp., 25,000-lb. per hr. evaporators supplying 150-lb. process steam.
2 DeLaval Steam Turbine Co., 200-g.p.m. motor driven evaporator feed pumps.
2 DeLaval Steam Turbine Co., 200-g.p.m. motor driven evaporator drain pumps.
2 DeLaval Steam Turbine Co., 150-g.p.m. makeup pumps.
2 Cochrane Corp., 10,000-g.p.h. water filters.
1 Niles Bement Pond Co., 40-t. turbine room crane.

into play. By changing valves, the entire quantity of boiler feedwater is caused to pass through the high heat level condenser, condensing the steam delivered to it from the evaporators. This condensate is collected in a drain tank from which it is pumped directly into the main feedwater line. All station drips are also put into this tank for reëntrance into the system.

With this makeup process in operation, there is of course an excess of feedwater trying to enter the circuit. The makeup pump develops a slightly greater head than the feed pumps and prevails. A part of the condensate from the prime movers, which would normally be pumped back to the boilers, is denied the privilege and having no other recourse, is directed to the head tank under the pressure given it by the condensate pump. From the head tank, it passes through the overflow to the

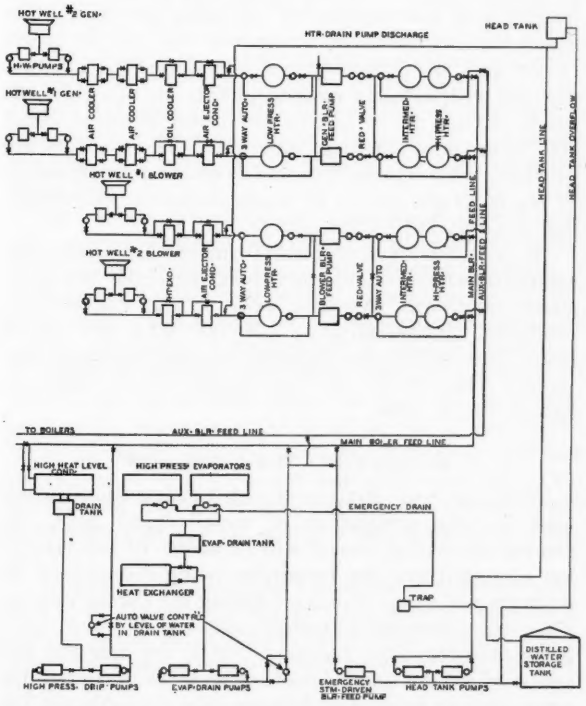

FIG. 7. DIAGRAM OF THE PURE WATER PIPING SYSTEM

ground tank and thus the water storage is increased as desired. The heat given up in the condensation of the steam in the high heat level condenser is absorbed by the main boiler feedwater so no heat is lost in the makeup process. Increased evaporator output is required but this demand is offset by the increased feedwater temperature and the corresponding decrease in fuel required per pound of steam delivered by the high-pressure boilers.

It may be seen from the foregoing that the boilers are supplied at all times with absolutely pure water. Thus far, no condenser leakage has occurred, hence no scale is in evidence. The boilers are never blown down and apparently can be run indefinitely without opening the drums. Actually, they are taken off the line once in four to eight weeks, primarily for cleaning of the external tube surface. At such times, it is the practice to open the drums for inspection because of the possibility of oxygen corrosion. Interior surfaces are treated with two coats of paint, adapted to resist corrosion, and after one year of operation, this coating is still intact. Several attachments inside the upper rear drum were not coated with the rest of the surface, however, and these also appear to be in good order with no evidence of corrosion.

It is doubtful if general corrosion would have occurred in any case. Gland leakage at the prime movers is kept at a minimum. The only other possibility for entrance of air into the system is at the surface of the water in the two tanks. It is thought unlikely that any appreciable amount of air enters at these points.

Only one steam driven auxiliary is installed in the power plant. This is the emergency boiler feed pump which draws water directly from the large distilled water storage tank, and pumps it directly into the main and auxiliary feed lines to boilers. The complete distilled water storage system contains about one million pounds of water.

Temperatures of the Walls of Boiler Furnaces

POWER PLANT engineers, when conducting tests to determine the efficiency of boilers, generally, allow a preliminary heating period of 4 to 8 hr.; they assume that in this time the walls are thoroughly heated and equilibrium is established so that the amount of heat leaving the wall on the outside is the same as that entering on the hot side.

Data taken by the Pittsburgh Experiment Station of the United States Bureau of Mines, Department of Commerce, show, however, that in walls 2½ or 3 bricks, 22½ or 27 in. thick, more heat was entering the brick than leaving it; that is, the temperature within the brick was still rising, even after periods of heating as long as 30 hr. A section of wall 13½ in. thick did not reach a state of thermal equilibrium in 8 hr. heating and a brick 2½ in. thick did not attain equilibrium until heated 2½ hr.

The data also show that in a furnace with solid brick walls of normal thickness, 18 to 27 in., which operate 12 to 16 hr. and are banked 12 to 8 hr. a day, a condition of thermal equilibrium is never reached. On banking, the inner several inches of wall cool rapidly and during steaming must again be heated so that more heat enters the wall than leaves it on the outside.

A 9-in. air-cooled wall was found to reach a state of equilibrium in about 10 hr. of steaming at normal boiler loads.

These data show that the rate of heat flow into the wall will not reach its constant and minimum value until many hours after lighting the fire; also, the inner wall will not reach its maximum temperature until constant conditions are reached, but its rate of rise becomes very slow as the constant rate of flow is approached and it will be approximately at its maximum temperature hours before the outer surface of the wall attains its maximum temperature.

FUEL OIL makes a satisfactory and convenient standby fuel although its storage in cities is usually subject to stringent regulation.

Fuel and Power Requirements of Steel Mills

Coke Making, Blast Furnaces and Mills Generate and Utilize Heat in Large Amounts with Some Surplus Left for Power. By Wilfred Sykes*

IN A PLANT manufacturing steel, starting with the production of iron from ores, the thermal reactions and direct application of heat are of primary importance. Secondary to such factors is the application of power for handling of materials, the manipulation and forming of the finished product. It is impossible, in the limits of available space, to give a detailed discussion of any of the main processes involving heat or the use of power but the following will be a brief discussion of the fuel and power requirements of the modern plant. As a basis will be taken a plant producing iron from ore and manufacturing steel in basic open hearth furnaces from the usual charge of iron and scrap. Of course, each plant will have individual characteristics which may change the figures given, but these figures will serve as a guide to indicate the fuel and power requirements of an ordinary plant.

Blast Furnace

For the production of iron in the blast furnace approximately 1800 to 2000 lb. of coke is required per gross ton of iron produced. The coke will usually have 88 to 90 per cent fixed carbon and have approximately 13,000 B.t.u. per lb. On a basis of consumption of 1800 lb., which would represent good practice using the usual Lake Superior ores, the fuel used in the blast furnace per gross ton of iron produced will be as follows:

$13{,}000 \times 1800 = 23{,}400{,}000$ B.t.u. per gross ton

Coke is used to provide heat which will enable the reactions for the reduction of the iron oxide to metallic iron, to be carried out and to provide also the carbon necessary for such reactions. The blast furnace, however, is not able to utilize the coke with 100 per cent efficiency. Apart from the heat losses, the chemical reactions limit the efficiency to which the carbon can be utilized. The carbon is used in two ways. At the high temperature existing, there is some direct reduction of the iron ores by the carbon; however, the main reaction is the burning of the carbon to CO_2, which immediately acquires an additional carbon molecule forming CO. This in turn reacts with the iron oxide in the ore and reduces it to metallic iron.

This reaction can not be carried out to convert all the CO to CO_2, consequently the gases which escape from the furnace usually carry about 25 per cent CO, which has not been utilized in the chemical reactions. In the case outlined above, a large heat value would be available in the gases leaving the furnace. The volume of the gas will be approximately 130,000 cu. ft. per gross ton of iron produced, which would average approximately 92 B.t.u. per cu. ft., representing a total of about 11,900,000 B.t.u. It will be seen that only about one-half of the carbon charged in the furnace is utilized in it and that the other half is rejected and must be utilized otherwise.

In the handling of these gases, losses will usually amount to approximately 600,000 B.t.u., leaving a net available heat value of the gases of 11,300,000 B.t.u. per ton of iron.

Air used for blowing the blast furnace is preheated usually from 800 deg. to 1200 deg. F., and to preheat the air, approximately 30 per cent of the gas from the furnace is used, or in this case about 3,500,000 B.t.u. per ton of iron, leaving available for other purposes about 7,800,000 B.t.u.

This gas is generally burned in boilers which supply steam for the operation of the blowers and for the production of power. In some cases, it is used for the operation of gas engines for the same purposes. The general trend, however, is towards the use of steam power and the figures given below represent actual practice with a fairly modern plant. In this case, the gas is burned under boilers producing steam at about 300 lb. pressure, 200 deg. superheat. These boilers are provided with economizers and consume approximately 17 cu. ft. of gas per lb. of steam produced, corresponding to about 1610 B.t.u. per lb.

In a group of four blast furnaces, the steam consumption, with turbo blowers operating under the above steam conditions, averaged 1470 lb. per ton of iron produced, corresponding to 2,360,000 B.t.u. per ton of iron. This leaves gas available for other purposes, containing 5,440,000 B.t.u. The disposal of this heat will be referred to later.

Economy in Coke Production

With the usual mixture of high and low volatile coals used for the production of metallurgical coke, the amount of coke produced will be about 70 per cent of the coal charged, the remainder being represented by moisture and gases driven off during the coking process. This coke contains a certain amount of small sizes unsuitable for blast furnaces, which are screened out and used as fuel under boilers or sold for domestic purposes, the net amount of furnace coke available per ton of coke being approximately two-thirds of a ton.

To provide the heat required for carbonizing the coal, either a portion of the coke oven gas produced or blast furnace gas can be used. It is general practice to use coke oven gas as being the most readily available. This gas will average about 550 B.t.u. per cu. ft. The temperature required in the ovens is such that it can be readily obtained with the use of blast furnace gas and there is a tendency at this time to use blast furnace gas for heating the coke ovens, thereby liberating for other purposes a greater amount of the coke oven gas.

Due to the low heating value of blast furnace gas, its use for heating purposes is decidedly limited, as the flame temperature obtainable is insufficient for many purposes. The coke oven gas can be used for all purposes necessary in a steel plant, as any desirable flame temperature required can be readily obtained. The practice is therefore developing of using a portion of the blast furnace gas for heating coke ovens instead of using it all under boilers for production of power. Coke

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ovens, however, require a steady supply of gas and only a portion of the average amount available can be used for this purpose, the amount depending upon the number of blast furnaces in operation. The bulk of blast furnace gas is so large that gas holders for its storage are limited to such size as to provide only for equalizing the supply over short periods.

Approximately 30,000 cu. ft. of blast furnace gas are required per net ton of coal carbonized or 45,000 cu. ft. per net ton of furnace coke produced. To carbonize the 1800 lb. or 0.9 t. of furnace coke per ton of iron will therefore require:

$45{,}000 \times 0.9 \times 92 = 3{,}720{,}000$ B.t.u. in blast furnace gas per gross ton of iron produced.

Power from Gas

This leaves available from the blast furnace gas approximately 1,720,000 B.t.u. per ton of iron produced, which can be utilized to provide for generation of power. In the power plant, using turbine generators and steam at about 270 lb. and 200 deg. superheat, it has been found that on an average over a year it will require about 20,000 B.t.u. per kw-hr., so that the surplus gas available for power, as outlined above, will represent about 86 kw-hr.

As gas supply and power requirements do not coincide, and on Sundays, when the furnaces are in operation and the mills are shut down, there is naturally a large amount of gas to be wasted, it has been found that only about 75 per cent of the theoretical amount of power that might be generated is actually produced.

Provided that the coke ovens are heated with blast furnace gas, as outlined above, for each net ton of coal carbonized, approximately 10,500 cu. ft of gas at 550 B.t.u. per cu. ft., will be available. This will represent 16,000 cu. ft. of gas per net ton of furnace coke. On the basis of 1800 lb. of coke per ton of iron there will be 14,400 cu. ft. per ton of iron which is equal to 7,930,000 B.t.u.

In addition to the above are produced approximately 15 gal. of tar per net ton of furnace coke, which will average about 153,000 B.t.u. per gallon. This will represent 13½ gal. per ton of iron produced, or 2,060,000 B.t.u.

Open Hearth Furnace Operation

Apart from the blast furnaces, the open hearth is the largest direct consumer of fuel in the steel plant. It will generally require approximately 5,000,000 B.t.u. per ton of steel produced, based on the common practice of a charge of approximately 50 per cent molten iron and 50 per cent scrap. Due to the loss in the furnace, it will require approximately 0.55 t. of iron per ton of steel produced. Assuming that coke oven gas and tar are used for fuel for the production of steel, the following amounts will be available per ton of steel:

$$\begin{aligned} 7{,}930{,}000 \times 0.55 &= 4{,}350{,}000 \text{ B.t.u.} \\ 2{,}060{,}000 \times 0.55 &= 1{,}130{,}000 \text{ B.t.u.} \\ &\overline{\quad\quad} \\ &5{,}480{,}000 \text{ B.t.u.} \end{aligned}$$

From the foregoing, it will be seen that, with the surplus coke oven gas and the tar, it is possible to supply the heat required for the manufacture of the steel under the conditions outlined above.

This leaves the necessity of supplying by outside fuel the heat required for reheating the steel ingots in the soaking pits and in the reheating furnaces for the finishing mills, as well as the fuel necessary to supply the additional power demands beyond that available from the surplus gas from the blast furnaces.

Fuel required for purely reheating purposes will vary greatly with the type of furnace used and the material to be reheated. These factors will again be greatly influenced by the layout of the plant, which will determine whether or not steel, which is to be reheated, may be charged hot. The following figures will indicate in general the order of these heat requirements, being based on average monthly operating conditions.

TABLE I. AVERAGE FUEL REQUIREMENTS OF REHEATING FURNACES

Furnaces	B.t.u. per ton production of mill
Soaking pits for 40-in. blooming mill. Producer gas	990,000
Continuous furnaces for 28-in. rail and structural mill, large part of steel charged hot. Coke oven gas	2,280,000
Continuous furnaces for 24-in. bar mill, mostly charged with cold blooms. Coke oven gas	3,470,000
14-in. merchant mill, all cold charge. Producer gas	2,500,000
8 and 11-in. merchant mill, all cold charge. Producer gas	2,900,000
100-in. plate mill, all cold charge. Powdered coal	6,200,000
Sheet mill. Coke oven gas	3,750,000
Sheet mill annealing furnaces. Coke oven gas	2,200,000

From the foregoing, it will be seen that there is a certain amount of power which will be available from the surplus blast furnace gas. This will average approximately 65 kw-hr. per ton of iron produced. The total amount of power used in the plant will, of course, depend entirely upon the products made. The finishing of material to small sizes or into sheets requires a considerable amount of power and the variation in an ordinary plant may be easily in the ratio of 2 to 1, depending upon the products shipped. The following figures are indicative of the power consumption of different types of mills and also of the auxiliary power that is used in a plant.

TABLE II. POWER CONSUMPTION OF TYPICAL ROLLING MILLS PER TON OF PRODUCT

Mill	Product	Power Consumption (kw-hr.) Main Drives	Auxiliaries
40-in. blooming mill.	Average bloom 75 sq. in. from 27 by 27 in. ingot.	16	5.5
28-in. 3-high mill.	Rails and structural shapes	36	5.5
24-in. billet mill.	4 by 4 billets from 8 by 8 blooms	11	...
100-in. plate mill.	Plates from slabs	37	15.5
19-in. continuous sheet bar mill.	Sheet bar from blooms	27	...
24-in. 2-high reversing bar mill.	Universal plates and structural shapes from blooms	48	14.0
14-in. merchant mill.	1 to 2½-in. rounds, 1½ to 3½-in. angles	45	8.0
8 and 11-in. merchant mill.	⅝ to ¾-in. rounds and squares. Small flats, etc.	90	4.0
Sheet mill.	Average gage—21	80	11.0

TABLE III. POWER REQUIREMENTS OF DEPARTMENTS OTHER THAN ROLLING MILLS

Department	Power Consumption Kw-hr. per Ton of Product
Blast furnaces, including ore docks.	15.0
Coke plant	6.5
Open hearth, auxiliaries	4.6
Fans	6.0
Water supply per ton shipped	20.0

The foregoing figures give some indication of the fuel and power requirements of an ordinary steel plant but so many combinations are possible that each case is a problem in itself and the actual figures in different plants may vary considerably from the figures quoted.

STEAM ECONOMY in the BEET SUGAR FACTORY

*By F. W. McEntire**

Due to the intricate use of steam in the manufacture of beet sugar, extreme care in routing the product and maintaining steam pressures and temperatures is demanded

MANUFACTURING beet sugar involves, primarily, the processes of heating and evaporating. Steam for these purposes comes ultimately of three sources: one direct from boiler plant, one indirect from boiler plant through engines as exhaust, and one as vapors from the evaporators. Each has a different value, both as regards cost and heat. The number of steams and vapors available depends upon the number of pressures under which the engines exhaust and upon the number of evaporators in that station of the factory. A quadruple effect has three vapors for heating and evaporating and the quintuple produces four. In the former, the first, second and third and in the latter, the fourth, may be added. They are listed as follows:

TABLE I. STEAMS AND VAPORS AND THEIR PROPERTIES WITH QUINTUPLE EVAPORATOR

	Gage press. lb. sq. in.	Temp. Deg. F.	Heat of liquid	Heat of vaporization	Total heat in steam
Live steam	135	358.5	330.2	863.2	1193.4
Boiling main	75	320.3	290.5	893.9	1184.4
High exhaust	50	298.0	265.7	911.0	1178.5
Standard exhaust	15	250.3	218.8	945.1	1163.9
First vapors	9	237.0	206.0	953.5	1159.5
Second vapors	4	225.2	193.4	961.8	1155.2
Third vapors	2" vac.	209.0	176.0	971.0	1149.0
Fourth vapors	12" vac.	188.3	156.2	985.0	1141.1

Just what values may be assigned to any of these steams for process work has long been a debatable question, one which depends upon the point from which the problem is attacked. The agreement of the factory operator may be that steam is necessary for propelling the pumps and engines and, therefore, free to the process. On the other hand, the mechanical department may claim that the boiler plant was built for heating and evaporating and, therefore, power costs consist of interest on engine investments and on engine men.

Of course, the fact of the matter is that the boilers were installed to serve the plant as a unit. The problem, then, is for the plant designer to install the machinery, engines, heaters and evaporator equipment in such a way as to give greatest economy in both labor and fuel, also for the operating and mechanical departments to reduce themselves to one unit united in the greatest effort for economy in fuel.

One Ton of Coal Slices 6 to 10 T. of Beets

This article is not concerned with the actual cost of steam generation but with its economical use. It will, therefore, suffice to state that one ton of coal will slice from 6 to 10 t. of beets and produce from 1 to 1.25 t. of sugar. A beet sugar factory operates for a period of about three months out of each year. It is, therefore, impossible to spend as much money in its boiler plant as would naturally be spent in the erection of an up-to-date power plant which runs twelve months out of the year; the last three or four per cent efficiency to be gained would never pay for itself. They are, however, regularly supplied with the following equipment for efficient operation: Suspended arches, soot blowers, steam flow meter, over fire air heated from breeching, automatic CO_2 recorders, automatic regulation on dampers and stoker engines, draft gages, flared or mechanically operated coal chutes, revolution counters on stokers, steel gages to set stoker gates and natural draft. Beet sugar boiler plants, as a rule, are sadly devoid of economizers.

Efficiency, overall, ranges 65 to 75 per cent depending on boiler settings. Firemen are instructed to maintain a tinge of smoke and keep furnace as hot as refractories will withstand. Coal consumption is calculated at end of each shift from revolution counters on stokers and fireman's notes on depth of coal bed.

As the process primarily is one of heating and evaporating, it is apparent that the quantity of dilution of juice should be reduced to a minimum with all due regard, of course, to consistent exhaustion of sugar from beets. The number of juices and liquors to be heated and evaporated are as listed in the Heat Use Table—1928 Campaign, of a Steffens and a Non-Steffens factory. The table serves as a flow sheet through the factories.

TABLE II. HEAT USE TABLE—1928 CAMPAIGN

Steffens Factory								Non Steffens Factory						
Station	% on Beets	Bx°	Temp. °C. To	Temp. °C. From	B.t.u.	#/lb Exh.	Vapor	% on Beets	Bx°	Temp. °C. To	Temp. °C. From	B.t.u.	#/lb Exh.	Vapor
Battery														
Beets	100		15	72	2450		1-2.6	100		20	65	2380	#2.29	
Draft	145	13.7	62	35				150	13.2	60	38			
D.J.Hr.#1	145	13.7	35	60	5780		3-5.9	150	13.2	38	80	2970		3-3.0
D.J.Hr.#2	145	13.7	60					150	13.2	80				
D.J.Hr.#3	145	13.7		85	5840		2-4.0	150	13.2		80	7200		1-2.5
1st Ch.Hr.	175	13.0	80	95	4250		1-4.4	150	13.2	80	90	2450		
2nd Ch.Hr.	171	13.0	80	95	3910	#4.13								2-0.6
3rd Ch.Hr.	171	13.0	95	95	2770		1-2.9	151	12.3	90	98	599		1-1.5
J.Boiler	169	11.8	65	98	3050		1-3.7	150	12.3	90	96	1449		1-4.1
J.Boiler								155	12.8			5020		1-1.4
M.J.Hr.	186	11.8	95	110	2000		1-3.1	155	12.8	90	96	1377		
1st Evap.	186	11.8	105	110	1900	1.59		153	12.8	96	115	4270	4.58	
1st Evap.	132	16.6			51700	54.70		107.5	16.2			44350	45.90	
Evap.K.J.	40.6	56.0						30.5						
H.W.sts.	25.6							29.7						
1st Pan	66.4	63.4			21100	#24.40		60.5	65.8			17500	#19.60	
Melter	25.6		62	90	480	.24		42.1	65.8	96	98	1338	# 1.35	
K.J.Sulph.	66.4		71	92	1510	#1.75								
K.J.Hr.														
H.W.Tk.	21.4		55	95	920	.96		18.1	65.	55	97	613	.62	
R.O.Tk.	12.7		55	90	230	# .50		17.8		55	65	593	.60	
R.O.Sulph.														
2nd Pan	12.7	70.0			3360	#3.89		17.8	67.0			5430	5.06	
Stf.Mol.Tk.								2.3		80	90	148	.15	
Sacch.Hr.	38.0		80	85	5390	5.40								
Stf.Waste	73.1		19	85	6080	6.27							9.25	
Waste						10.65								
Total					125690	115.48	28.6					98538	99.36	22.7

Notations: D.J indicates Diffusion Juice
M.J indicates Thin Juice
K.J indicates Thick Juice
Bx indicates Brix

# indicates live steam boiler pressure otherwise exhaust
First figure in vapor columns indicates the vapor used, i.e. 1 - 1st vapor

Outline of Diffusion Cell Operation

Juice is obtained from the beets in the diffusion tank cells. It is on this station that steam first comes into use in the process and it is here also where its greatest

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losses occur. A problem of steam economy may best be explained by a brief description of the operations of this station.

In Fig. 1 is shown a typical diffusion cell and heater. The beets, after being thoroughly washed, are sliced with "V" shaped knives, packed in the cells and covered with water at about 60 deg. C. under pressure of 40 lb. per sq. in. From 14 to 16 of these cells and heaters are connected in series. The water is forced down through the slices in the cell, up through the heater and down through the next cell and so on, picking up sugar and reducing sugar content of cossettes until usually twelve tanks have been filled. Heat is applied to break down the cell structure of the slices, i. e., soften the cells but not rupture them. The desired effect is reached at a maximum temperature in the juice from 78 to 85 deg. C., this varies directly with the capacity at which the station is run, also the type of beet.

Products of this station are raw juice of from 10 to 15 Brix from the last tank filled and exhausted cossettes called pulp containing 0.20 per cent sugar from the first tank filled. The degree Brix of the raw juice and sugar content of pulp depends upon the temperature and quantity of water forced through the slices and the time involved. Assuming that temperature and time are set by capacity at which the station is being operated, the quantity of water then becomes apparently the only variable factor. With the operator under instructions not to discharge the pulp higher in sugar content than 0.20 per cent and to maintain the Brix of the juice as high as possible, it is apparent that he will want perfect circulation of water through the chips and thus obtain the best diffusion.

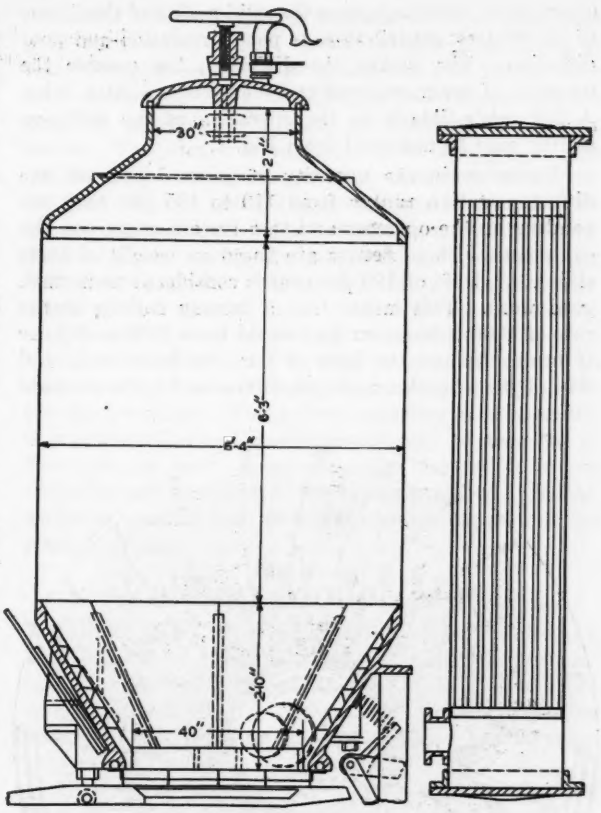


FIG. 1. DIFFUSION BATTERY CELL AND HEATER

To obtain perfect circulation requires a firm and perfectly cut chip of proper thickness, perfectly packed in the cells. A thick heavy chip aids circulation but hinders diffusion. Chips cut too thin or those cut with dull knives producing ragged chips, have a tendency to mat together and retard circulation, resulting in poor diffusion. Again, good chips packed unevenly in the tanks, for instance, more solidly on one side than on the

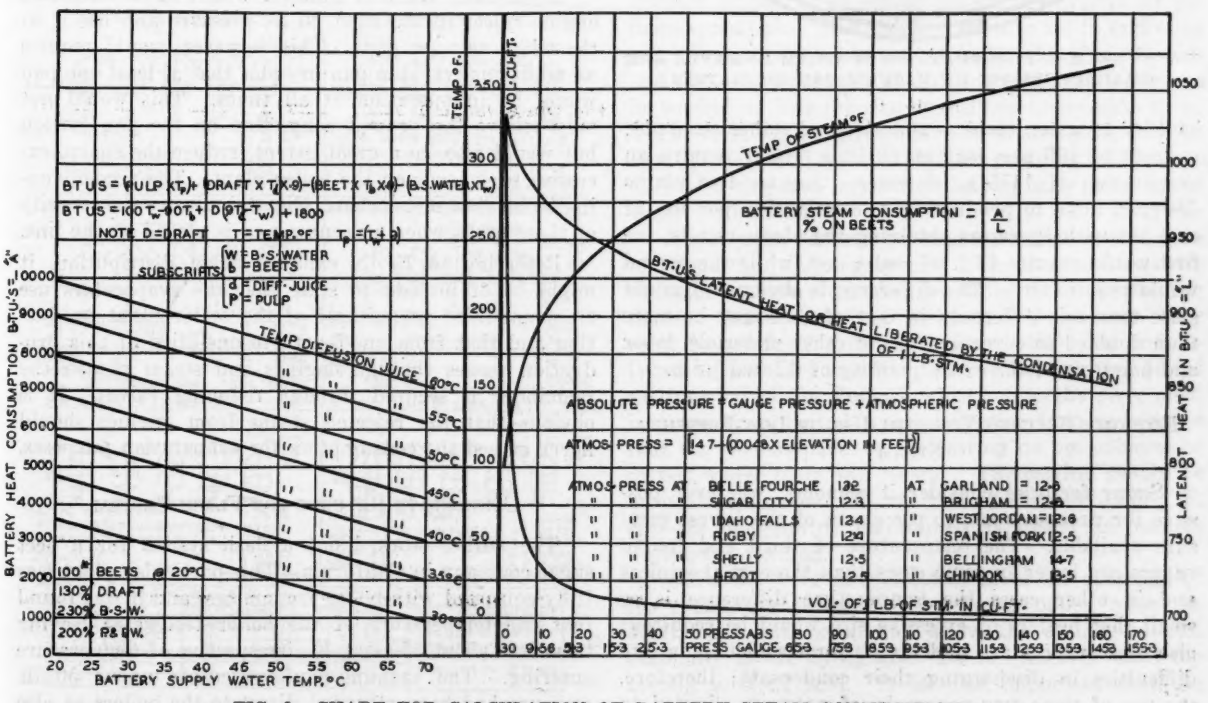

TEMP °F.
VOL. CU. FT.
TEMP OF STEAM °F
BATTERY STEAM CONSUMPTION = A/L % ON BEETS
B.T.U.'S LATENT HEAT OR HEAT LIBERATED BY THE CONDENSATION OF 1 LB. STM.
ABSOLUTE PRESSURE = GAUGE PRESSURE + ATMOSPHERIC PRESSURE
ATMOS. PRESS = [14.7 − (.0004 8 X ELEVATION IN FEET)]
VOL. OF 1 LB. OF STM. IN CU. FT.
BATTERY HEAT CONSUMPTION BTU'S = A
LATENT HEAT IN BTU'S = L
BATTERY SUPPLY WATER TEMP. °C
PRESS ABS
PRESS GAUGE
100# BEETS @ 20°C
130% DRAFT
230% B.S.W.
200% P & B.W.

FIG. 2. CHART FOR CALCULATION OF BATTERY STEAM CONSUMPTION

other, cause water to bypass the solid pack and this is one of the greatest contributors to poor circulation and poor diffusion. The poorer the diffusion, the greater the quantity of water required and therefore a diluted juice. A few other details on the operation of the diffusion station may be deducted from Fig. 2.

Variation in the quantity of juice drawn off the diffusion station ranges from 110 to 165 per cent, depending on the operator and to a certain degree on the equipment. These figures are based on weight of beets sliced. A draft of 120 per cent is considered as normal, good work. This means that a factory cutting at the rate of 1000 t. beets per day would have 1200 t. of juice to heat. Assume the Brix of the thin juice at 12 and that of the white vacuum pan fillmas at 94; there would

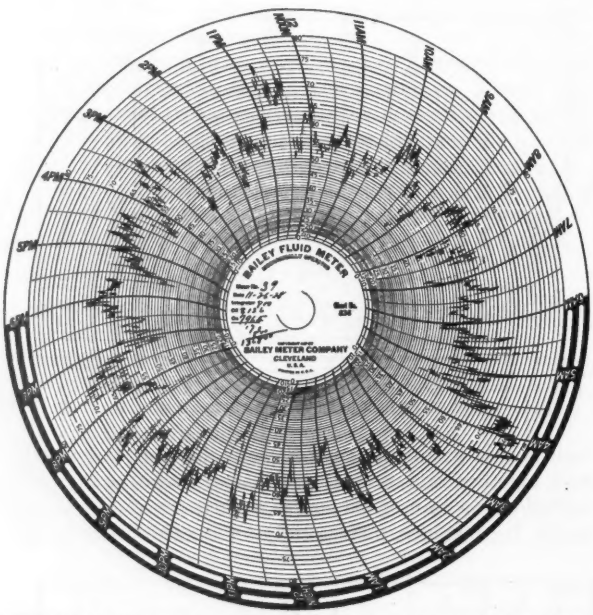


FIG. 3 SEVERE FLUCTUATIONS IN STEAM DEMANDS ARE CHARACTERISTIC OF VACUUM PAN OPERATION

be 1048 t. water to be evaporated. Another example: a draft of 165 per cent at 10 Brix would require an evaporation of 1475 t. of water. Assume two plants designed alike to produce 25 t. evaporation per ton of coal but with operators obtaining the above results, the first would require 42 t. of coal a day, while the second would require 59 t. The difference is obvious. I might state that this difference in cost of coal may be more than doubled to cover expense of other materials, labor and handling of the extra quantity of diluted juice.

Economy Secured Through Use of Low-Pressure Steam

Sugar factories consider it economy, wherever possible for process work, to use steam of the lowest pressure available. The temperature of third and fourth vapors are lower in some cases than those of the juices and in other cases the temperature difference is so small that heaters of excessive size would be required; also these vapors are under a vacuum which leads into difficulties in discharging their condensate; therefore, the use of these two vapors is, of necessity, limited to heating raw diffusion juice which has a temperature varying from 30 to 45 deg. C. (see Fig. 2).

Second vapors which are always under pressure are next in line of economy and are, in general practice, used throughout the plant for heating purposes. First vapors are at times used when size of heater is small and where a higher temperature than that of second vapors is deemed necessary. It also comes into use on brown sugar vacuum of pan colandra type.

Exhaust at 15 lb. pressure is always used on first body evaporators and also on brown vacuum pans of coil and colandra types. It has to a small degree been used on white vacuum coil pans. These bring us about to the end of low-pressure steam applications.

General practice on white sugar vacuum pans is to use live steam, reduced to 80 lb. gage pressure. A factory in California, however, uses engine exhaust at 50 lb. gage pressure for this work. While in other plants, live steam under 145 lb. pressure direct from the boiler plants is used. The use of this high-pressure steam has been forced upon a few plants which have increased their capacity without addition to vacuum pan station; this is the case in the instance of plants which were originally designed for 600 and 800 t. beets per day, but are now operated at 1200 and 1500 t. respectively.

There is a growing problem which may lead to a more general use of 50 lb. exhaust steam, because of conditions brought about by the magnitude of purchased electrical load. The increasing cost of this power will eventually force us to replace present belted engines with electrical generators and motors or to add a generator engine to the present power equipment. In the former case, the generator engine would exhaust at 15 lb. pressure and the steam distribution would remain as at present; but, in the latter case, this additional engine would overload the 15 lb. exhaust system or compel the uneconomical use of exhaust for heating purposes.

Apparently the best solution would be to have this engine reject its steam at 50 lb. pressure and use it in the white vacuum pans. This, however, would require an additional vacuum pan in order that at least one pan would be in operation at all times. This would not only relieve the present congestion on the pan station but would also, to a great extent, reduce the sharp, excessive peak loads on the boiler plant. The accompanying boiler flow meter chart, Fig. 3, indicates the severity of these peaks when a vacuum pan is placed on the line.

Referring to 15 lb. exhaust steam distribution, it might be of interest to state that the evaporators use from one-third to one-half of the boiler plant production and that from one-fourth to one-third of this production passes through engines and steam pumps the remainder is secured through reducing valves. It is obvious that the rejected steam from engines should never exceed the consumption for evaporation purposes.

Condensate Returns for Flash System

The author worked out a flash system for a beet sugar company in California. This particular plant was fully equipped with boiler economizers and it was found that the temperature of the boiler feedwater leaving them was about 330 deg. F., irrespective of temperature entering. The vacuum pan condensate under 50 lb. pressure had been returned direct to the boilers as also

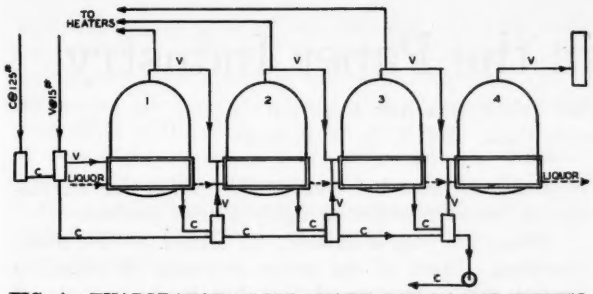


FIG. 4. EVAPORATOR FLOW CHART FOR FLASH SYSTEM

was some condensate under 15 lb. pressure. The scheme of the flash system, was to inject the condensate at 50 lb. pressure through traps into the condensate at 15 lb. pressure and use the flash thereof in the 15 lb. exhaust steam system. In a like manner, the combined condensate at 15 lb. was then injected into the first evaporator condensate which flashed to first vapors. This idea was carried out on down through the second and third vapors until the condensate reached a temperature of about 85 deg. C. the temperature of hot water used throughout the factory.

The amount of steam liberated between 50 lb. exhaust and third vapors into steam system of the factory was considered as an absolute gain on account of the magnitude of the economizers. It may be indicated as follows:

	Heat of condensate per pound
50 lb. condensate.....	267 B.t.u.
Third vapors	180 B.t.u.
Total flash	87 B.t.u.

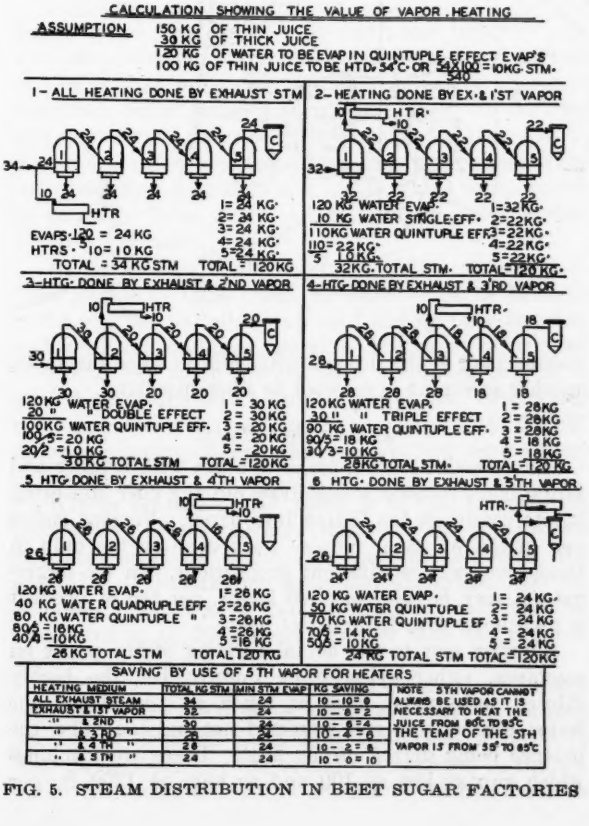

CALCULATION SHOWING THE VALUE OF VAPOR HEATING
ASSUMPTION 150 KG OF THIN JUICE
30 KG OF THICK JUICE
120 KG OF WATER TO BE EVAP IN QUINTUPLE EFFECT EVAP'S
100 KG OF THIN JUICE TO BE HTD. 54° C. OR 54X100 = 10KG STM.
540
1- ALL HEATING DONE BY EXHAUST STM
2- HEATING DONE BY EX. & 1ST VAPOR
3- HTG. DONE BY EXHAUST & 2ND VAPOR
4- HTG. DONE BY EXHAUST & 3RD VAPOR
5 HTG. DONE BY EXHAUST & 4TH VAPOR
6 HTG. DONE BY EXHAUST & 5TH VAPOR
SAVING BY USE OF 5 TH VAPOR FOR HEATERS
HEATING MEDIUM
TOTAL KG STM
MIN STM EVAP
KG SAVING
NOTE 5TH VAPOR CANNOT ALWAYS BE USED AS IT IS NECESSARY TO HEAT THE JUICE FROM 60°C TO 85°C THE TEMP OF THE 5TH VAPOR IS FROM 35° TO 85°C
ALL EXHAUST STEAM 34 24 10 - 10 = 0
EXHAUST & 1ST VAPOR 32 24 10 - 8 = 2
" & 2ND " 30 24 10 - 6 = 4
" & 3RD " 28 24 10 - 4 = 6
" & 4 TH " 26 24 10 - 2 = 8
" & 5TH " 24 24 10 - 0 = 10

FIG. 5. STEAM DISTRIBUTION IN BEET SUGAR FACTORIES

Under the conditions, it was never known just what gain was made; we had no way of metering it but it was variously estimated at between 7 and 12 per cent aside from relieving several boiler feed pumps and the constant troubles with them in pumping the hotter water. The idea was carried out in another of this company's plants which was not equipped with economizers. In this plant, the saving was estimated to be 3.3 per cent, gained in not overheating water in hot-water well and escaping flash, besides removing boiler feed pump troubles. Figure 4 shows general arrangements of flash system.

In conclusion, a picture of steam distribution in a beet sugar factory may be seen to good advantage in diagram Fig. 5 on calculations of values of vapors for heating purposes. The general practice is a combination of Nos. 3, 4 and 5, with a tendency to drop No. 5. The rule, in short, in a beet sugar factory is to use steam for process work of the lowest pressure available, wherever possible, and to get the hearty support of the plant operators.

Welding Monel Metal

MONEL METAL is an alloy of nickel and copper containing about 67 per cent nickel, 28 per cent copper, with 5 per cent of other elements such as iron, manganese, silicon and carbon. In appearance, when new it resembles untarnished nickel and has valuable property of resistance to corrosion.

In welding Monel metal, a few simple precautions must be observed. First, a neutral flame should be used. The tip should be one or two sizes larger than would be required for steel of the same thickness. Cold drawn Monel metal wire or strips cut from sheet, should be used as welding rod. As a general rule, flux is not required, as the oxide film that forms on the surface of the puddle helps to protect the metal underneath from further oxidation. Keeping the outer envelope of the flame spread over the weld area will also aid in excluding air. The rod should be melted under this skin of oxide and slag. Any particles of dirt or foreign matter should be worked up into the slag by melting underneath them. Then, when the weld is built up well above the surface, as all Monel metal welds should be, grinding will remove all oxide, slag and impurities, leaving only good sound metal in the weld.

Monel metal castings present a peculiar combination of properties. Like gray cast iron, they are sensitive to sudden temperature changes while under the welding flame. Consequently, in welding such castings they must be carefully preheated, welded while hot and allowed to cool very slowly. Like cast aluminum, Monel castings have little strength when hot, so the piece must be properly supported in the preheating furnace in order that the various parts of the casting do not collapse or distort under their own weight. The casting should be brought to an even dull red heat of about 1200 deg. F. and the temperature maintained as steady as possible during the welding.

When the weld is completed, cover all openings of the preheating furnace with asbestos paper, close the draft holes with sand and allow the casting to cool gradually in the dying fire. Do not uncover until the casting is stone cold. It is most important that the annealing process be carefully carried out.

Heat and Power Uses in the Paper Industry

LARGE AMOUNTS OF STEAM, HOT WATER AND POWER ARE REQUIRED TO MAKE THE BACKGROUND FOR THE PRINTED PAGE. BY G. R. WADLEIGH*

PROBABLY, among all industries, excepting, perhaps certain electro-chemical processes, there is none in which low cost of production and efficient use of heat and power are more important than in the pulp and paper industry, for these items form from 15 to 25 per cent of the cost of conversion of raw material such as wood, esparto, straw, rags, into finished paper.

PREPARATION OF RAW MATERIAL

If we follow roughly the course of the raw material through the plant, we find, first, in the woodyard, assuming that wood is the raw material, power averaging 3 to 8 kw-hr. per cord required to operate conveyors, wood-washers, industrial locomotives and the like.

In the ground wood process of making paper, large quantities of power are required to operate the grinding stones, averaging 1200 kw-hr. per ton. When pulp is made by the chemical process, chipping prior to cooking calls for 15 kw-hr. per ton of finished pulp. The actual cooking in closed pressure vessels takes from 6000 to 10,000 lb. of steam per ton of product at a pressure ranging from 60 to 125 lb., depending on the particular chemical process used. Following the cooking is washing, requiring considerable warm water and, for both ground wood and chemical pulp, there comes screening, requiring no heat but considerable power for circulation of large quantities of highly diluted product.

Before the pulp is finished, for certain grades, comes bleaching. Some of the newer processes of bleaching require small amounts of heat but large amounts of power to circulate the high density material. Roughly, we might say that at this point are required 2000 lb. of steam and 25 kw-hr. per ton, if the old process is used and 75 kw-hr. per ton, if the high density method is used. Strictly speaking, this concludes the pulp-making part of the process, although, in some instances, another screening is resorted to after bleaching.

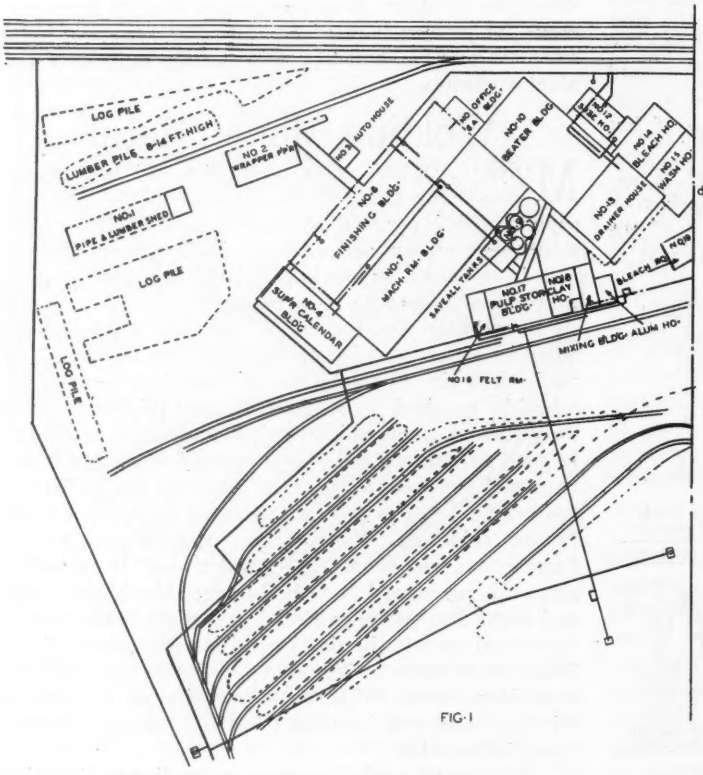


FIG. 1

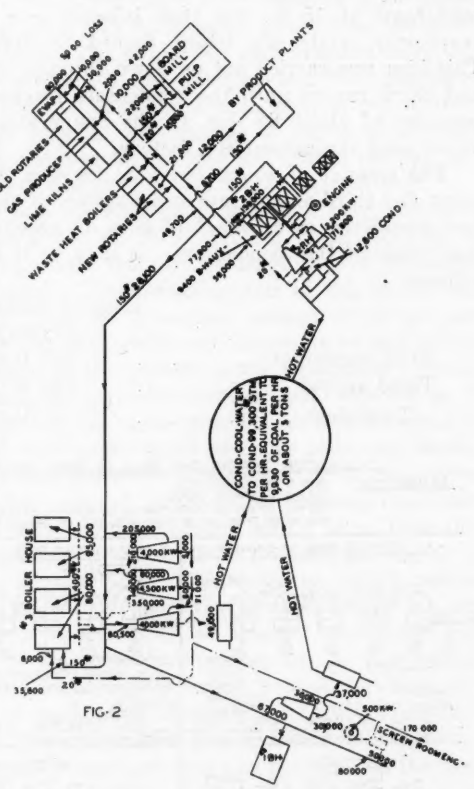


FIG. 2

MAKING THE PAPER

Paper-making is supposed to begin with beating and jordaning, processes which draw out the fiber and bring it into condition for felting into paper. Various makes and grades of paper require work done on the pulp in these two ways in different proportions. In the aggregate, it may be said that 400 kw-hr. per ton of product is used here, with little direct heat.

Coming now to the actual forming of the paper on machines, either cylinder or Fourdrinier, the highly diluted pulp must have as much as possible of the water drained off and squeezed out mechanically, the balance being driven off by heat. There are machines which run as low as 100 and as high as 1200 ft. per

*Manager, Engineering Dept., West Virginia Pulp and Paper Co.

min., on widths from 72 to over 300 in., with daily product running from a few tons to 130 tons a day. Driving of these machines takes approximately 700 to 800 kw-hr. per ton, while the drying of the paper takes from 5000 to 10,000 lb. of steam per ton.

After the paper is made, come various finishing processes—a quite common one being supercalendering —followed by winding, cutting, embossing, and the like. This finishing department may be said to take 60 kw-hr. per unit output.

By-Product Treatment

In addition to the direct manufacture of pulp and paper, as it has been outlined, are a number of processes that in connection with chemical pulp must be termed "side shows," making or converting chemical by-products. Some mills have a complete set of these; others buy material outside. For instance, soda and sulphate pulp require recovery plants, reclaiming 70 to 90 per cent of the soda and sulphur used in the process. Such a plant consists of evaporators, reducing furnaces of different types, dissolving tanks, causticising equipment, and lime burners for reclaiming, all requiring heat and power. At the same time, certain processes are exothermic and furnish heat for use elsewhere. The size of these by-product plants, for many mills, makes them equivalent to large-sized chemical industries in themselves.

Another auxiliary is the manufacture of bleach, of which large quantities are sometimes required. This process uses common salt as a raw material, from which chlorine is made by electrolytic cells. Here are required 1500 kw-hr. per ton, roughly, of bleach, and perhaps 300 lb. of bleach are required per ton of pulp.

Aggregate requirements for process heat and for power are so great in the pulp and paper industry and, with the exception of ground wood processes, interlock so closely that practically all such industries maintain their own boiler houses and power houses. In the case of ground wood processes, the demand for power overshadows the heat demand to such an extent that these industries find it profitable to locate where cheap power is available from water power sites, or from hydro-electric plants.

In the making of the products under consideration, from 50,000 to 150,000 gal. of water must be brought to the mill per ton of output, used largely for conveying and much for washing; and all of this must be pumped over and over again several times, acquiring heat as it goes through the mill. In the wintertime, such water may enter the mill at 33 deg. F. and leave at 80 deg. F. A large quantity of heat disappears at low temperature in this way.

Winter heating of the plant is of real importance, particularly in the northern climates. As the process goes on for 24 hr. a day, six days in the week, the providing of illumination is another drain upon sources of power. The winter load on a boiler house may be considered to be 20 per cent greater than the summer load.

Taking up in some detail the matters previously outlined, if say 8000 lb. of steam are used in cooking per ton of chemical pulp, heat equivalent of 6000 to 8000 lb. of steam per ton of pulp is required in the hot water for washing. Steps should be taken, then, to utilize the heat discharged with the stock when it is blown out of the digester, as the chemical action actually absorbs no heat. In many cases, this is now thrown away. Some mills use it for heating the water for stock washing. It has been proposed that the 8000 lb. per ton be blown into an accumulator and thence pass through a turbine directly or indirectly. As far as known, this last scheme is not in commercial operation.

From the washing of the stock there is a large quantity of water discharged containing heat at a low temperature level, perhaps 150 deg. F., the recovery of which for future use is at the present time not considered commercially possible.

Stock coming from a digester contains a large amount of liquor made up of water, the mineral salts used in cooking the wood, together with the ligneous material, the latter making up nearly 50 per cent of the weight of the wood. The combustibles in this material should be used, as far as possible, to help out recovery of the valuable inorganic salts within itself; at the same time, it is advisable to dilute this material as little as possible in washing, also maintain its temperature until turned into the evaporators at the initiation of the recovery process. In the sulphite process as much as 300 lb. of sulphur per ton of pulp is burned. The heat of this should not be thrown away.

Theoretically, heat is not required in the bleaching of stock, provided the plant has capacity enough; but commercially in most cases it has been found advisable, in order to expedite and increase production to apply heat to stock, bringing up to a temperature of about 115 deg F. This heat is generally supplied by the introduction of low-pressure steam. It can be supplied by preheating some of the diluted wash water through special heaters, taking steam from the digester blow, or from low-pressure lines throughout the mill. Certain bleach processes, known as "high density," work better at lower temperatures but require the addition of compressed air to expedite oxidization of the objectionable material. Here again is another demand for power.

Pulp, if not to be used directly in slush form in an adjoining paper mill to which it is pumped, is prepared for storage or shipment by squeezing out all water possible mechanically, then drying to 15 per cent moisture by the use of heat, if freight rates warrant this additional preparatory cost. For these two processes, 100 to 200 kw-hr. and 3000 to 5000 lb. of steam are required per ton of dry product.

Some recovery of heat is possible from this process, in that the condensate from the drying system can be collected and used for boiler feed, also a certain amount of heat can be taken out of the more or less saturated air, which leaves the dryers at a temperature of perhaps 120 to 130 deg. F.

Operation of Paper-Making Machines

Of beating and jordaning, there is little to add to previous statements, except that the mechanical action of the machines heats the stock an appreciable amount. Careless installation and use of machines and pumps can, in a few moment, add large blocks of power to the demand on a steam or power plant, without corresponding gain in product.

After the pulp is placed in the proper condition for felting into paper, the paper machine combines four

methods of separating pulp and water. These methods are, natural drainage of the water from the pulp, pushing out the water from between the pulp fibers by air pressure through creating a vacuum on one side of the sheet, mechanical squeezing out of the water by compressing the bundles of fibers and the evaporation of water by heat. Power is required for keeping in motion the Fourdrinier wire, permitting gravity drainage, while the suction boxes and rolls are necessary to the second method mentioned. This second method requires a large amount of power for the operation of vacuum pumps, as much as 500 hp. per machine. The squeeze rolls may take 100 hp. per pair of rolls, and the dryers, in connection with the heating, may require 200 to 250 hp. for large machines. In addition, the low-pressure steam, as previously stated, is 2½ to 3½ lb. per pound of dry paper made. After the separation of water and fiber, calendering follows, requiring up to 200 hp. per calender for large machines, some machines running three calenders.

Having roughly shown the picture of heat and power requirements, the supplying of this heat and power, its economical utilization, proper regulation and reclamation of all heat possible constitute a large subject, which can be only lightly touched upon here. As an example, paper may go to the dryers 65 per cent water and leave 5 per cent water. Too rapid drying means defective paper; too slow drying reduces machine capacity. Theoretically, this process should all take place in a vacuum, with the possibility of using the vapors issuing from the sheet for the generation of power by passing them through a low-pressure turbine. There is a vacuum system on the market that is a long step in this direction, although it is not known that the utilization of the steam therefrom for power has ever been practically attempted.

In general, paper manufacturers are not, as yet, willing to accept the principle of vacuum drying but attempt the next best thing—drying with a minimum amount of air. For heat economy, this air should be as small in amount as possible and the temperature kept low. At atmospheric pressure, these two conditions are antagonistic. Commercially, we must compromise so as to obtain the best drying of paper, yet have air leaving the machine as nearly saturated as possible. The heat in the moist air coming from the paper machine ought to be utilized. This is done in certain mills with a heat interchanger, the heat thus conserved serving to help dry out the paper and maintain the proper temperature in the plant during the winter. Many mechanical difficulties are encountered in collecting this air and directing it towards an economizer of the type mentioned, or in using it for heating process water as is proposed by one concern.

Paper-making is still much of an art, but science is being rapidly applied to much of it through application of heat balance studies, helped out by the free use of meters of various kinds. Only a few years ago, outside of electrical instruments, almost the only measuring instruments used by the paper manufacturer were a steam gage, perhaps a speed indicator, a scale and a 4-ft. rule. At the present time, many flow meters for water and steam, barometers, vacuum gages, hygrometers, and thermometers are in general use. Progress is being made in the use of automatic moisture indicators for paper, salinity meters, recording hydrometers, viscosometers and density recorders.

Paper Mill, Operation Problems

To supply the kilowatt-hours and the heat units at the various steam pressures desired, also pump water for processes, requires a quite sizable plant. The old target of mill superintendents was to keep coal required per ton of pulp and paper down to one ton. This target was something to aim at, but was practically never hit; few had any expectation of reaching it. At the present time, many pulp and paper mills are bettering this figure, notwithstanding that more power is used per ton of product and much more exacting conditions are required in the way of keeping temperatures and pressures constant.

Assuming no outside source of power available, the economical procedure is to make steam at high pressure, pass it through turbines, bleeding at the several stages required for process work, and send a minimum amount to the condenser. This condensing temperature should be such as to furnish the necessary heat to warm water required by the mill at the proper temperature. A preference might be expressed by some for the use of reciprocating engines at the higher pressures, rather than turbines.

Under certain conditions, notably in a chemical pulp mill, purchasing outside power, the use of a heat accumulator is advisable, to simplify the question of heat balance.

In connection with the recovery plants of chemical pulp mills, a number of the reactions are exothermic and certain mills abroad have been able to operate burning no coal at all, all process heat coming from the recovery plant operation with small amounts of power coming in from an outside source, such as hydroelectric plant. Such a situation is greatly aided where, due to limited markets for much of the time, there is an abundance of current at low prices. Here the electric boiler is used, sometimes in large sizes.

It can hardly be expected that the steam and power production process in the pulp and paper industry will be in advance of the work of the public service stations, as in the latter case cheap production of heat and power is their major object, to which all technical talent is applied. With the pulp and paper industry, energy is only one of several things to be manufactured and is almost never marketed directly. In spite of this, one pulp and paper mill is operating a plant at 600 lb., several more are under construction and several are operating in the vicinity of 400 lb. Needless to say, all of these are equipped with the best type of boilers, furnaces, stokers or pulverized coal, and economizers, air preheaters, apparatus for feedwater treatment, and other auxiliaries.

Dirt from the stack is quite as serious a problem for a pulp and paper mill as it is for a public service station in an urban district.

Requirements Are Complex

Design of a power plant for the industry under consideration is considerably more complex than that of a central station, due to the three or four products,—that is, kilowatt-hours, high-pressure steam, low-pressure steam and warm water,—all to be produced at the lowest

possible coal consumption, which means keeping the output in balance with the demands of the manufacturing department at a minimum of fuel and labor cost, utilizing, at the same time all possible heat from the various exothermic processes.

In addition to the above, a thorough knowledge of turbines,—both non-condensing and condensing—condensers, air compressors, vacuum pumps, electrical generation and distribution and refrigerating plants is desirable; all of these coming under the control of the plant operator in a modern pulp and paper mill.

Regulation is one vital question which has received less attention than it should in the industry. Automatic devices are used as far as possible. The proper selection thereof can only be made when a joint knowledge exists of the heat cycle, the capacities of the instrument itself and the process to which it is to be applied. Regulators of all kinds are used, operating on steam pressures, temperatures, expansions of parts, change in density of product, change in humidity of product,—working through every means of power conversion, even radio. But much more can be done than has been done to date along this line.

Real Men Are Needed

Most important of all the factors entering into the application of heat to the pulp and paper industry is that of personnel. The return that can be made by an adequate operating force under the highest class of leadership is often overlooked by the management.

Not long since operation of the heat and power plant was in the hands of the paper-mill superintendent, who delegated his authority to an engine operator, often with no more real knowledge of the subject than a high-class mechanic would have. If such a man burned the coal furnished him, kept the bills normal, with everything moving, the power plant reasonably neat, and furnished all the steam to the production force that was wanted at any place, at any time, no more was asked of him.

"Heat and Power" was in no way rated as a department, although yearly expenditures and value of output amounted to $1,000,000 or more in the larger plants. The salary of a skilled mechanic was considered ample pay for such a man, notwithstanding the fact that a slight lack of technical knowledge or an error unobservable or not understandable to the mill superintendent would cost the company ten times the salary paid that man. No books were kept other than the record of tons of coal per ton of pulp. Between these two extremes, could be a half dozen machines or processes, inefficient from the heat standpoint, which were supported by the efficient ones, but nothing in the accounting system would point them out.

Now, to the benefit of all concerned, conditions in the best plants are much changed from those just outlined. The Heat and Power man's arm reaches all the way from the purchase of fuel to steam used in the last ¼-in. valve and the purchase of lighting bulbs. He is in advisory control of the production of vacuum for suction rolls, heating and ventilating of the machine room, the supply of compressed air, water purification, operation of the refrigerating plant for acid-making and operation of reducing furnaces. He is a man who knows heat in all its phases and effects; he must have some knowledge of chemistry; be a good mechanic; something of an accountant; must readily handle commercial help; must be tactful; an organizer and teacher; responsible to the plant manager for a department with a profit and loss account. His raw materials are coal, air, water, man-hours and supplies. His product is kilowatt-hours, process steam at one or more pressures, water at various temperatures, perhaps heated air, and on these items he should show a manufacturing profit, the same as any other department. His competition is the price at which these products could be purchased outside.

To carry on such a department successfully means an adequate working force, well taught and well paid. An investment in such a force with liberal appropriation for meters and instruments, will pay large dividends even when using old equipment; often many times more than the investment in new and modern steam and power producing equipment, if this latter is operated under the old method of organization in which Heat and Power is considered a non-productive department and a necessary evil.

Colds, Flu, or What Have You?

By Elizareth Cole

ARE YOU one of the many men or women who are constantly taking cold and feeling miserable? The common cold, as it is called, for years has been dismissed as being a minor ailment. Yet it is really a serious handicap not only to health but to industry. It can be the precursor to influenza, pneumonia, tuberculosis of the lungs, and other really serious diseases.

Influenza, which is often confused with colds, caused 25,000 deaths in the United States during the year 1927. How many deaths from pneumonia, tuberculosis and other more serious diseases followed in the wake of flu, our statistics do not tell, but we know that they were many.

Yet these seemingly minor illnesses in the winter can be reduced, if people will only take the matter of health more seriously. As a matter of fact, health is contagious and can be caught as easily as we can catch measles. Here are some of the ways by which we can catch health. We can get sufficient rest, that is, relaxation from routine, and enough sleep at night with windows open. We can walk in the fresh air or take some other regular daily exercise. We can eat simple foods, well-balanced and regular meals—more fruit, salads and vegetables. We can drink more water, at least six glasses a day.

The physically fit person is seldom susceptible to colds—it is usually the man or woman whose resistance has been lowered by fatigue, improper food or careless habits who is the common cold catcher.

One of the most serious results of a seemingly minor cold can be tuberculosis. Neglected colds and coughs are all too frequently forerunners of this disease. It is to make the public more alert to the dangers that may result from colds, flu, or what have you, that the National Tuberculosis Association and its affiliated associations conduct their educational campaign supported by Christmas seals.

Carbon dioxide refrigerating machines are in use producing temperatures of 40 to 50 deg. F. below zero.

DEPENDABILITY and FLEXIBILITY

Keynote of

POWER and STEAM

demands of the

MODERN HOTEL

—By—
KARR PARKER

FEW PEOPLE realize the complexities of the power plant installation in a modern hotel, the diversity and magnitude of the uses of steam and electricity, the quantities of water and refrigeration or the many intricate and interesting problems of the power engineer. Without elevators, steam, ventilating fans, electric light and signal systems, a hotel building would be uninhabitable so that a shutdown of the power plant completely disrupts the service of the hotel to its guests. Consequently reliability of service is of paramount importance and the engineer usually provides duplicate power plant equipment so that if a breakdown occurs on any machine, the duplicate unit can be put into service at once. Special attention should be paid to the piping and wiring systems so that the plant equipment will be flexible and reliable in operation.

Many engineering data have been accumulated from hotels now in operation. From this, it is possible to predict with a considerable degree of accuracy the electric power consumption of a new hotel to be built, its daily load factor and the quantities of both high and low-pressure steam that will be required at various seasons. Typical daily load curves for both steam and electricity demands can be plotted. For example, we know that the average annual electricity consumption per room of a large hotel located in the northern cities of the United States is 2700 kw-hr. but that the amount of steam required for heating depends more on the type of building, glass area, climate and other factors. With these calculations before us, however, it is possible to determine in advance the annual tonnage of coal that will be burned and the cost of electric power that will be required.

Low-pressure steam (2-5 lb. gage) is required during the heating season for supplying the building radiation. It is also required for heating the tremendous quantities of water which are used in a large hotel. The hot-water system is usually carried at a temperature of 140 deg. F. for the house and 180 deg. F. for the laundry and kitchen. Regulation is effected by means of thermostats on the water heaters. Water for the laundry may have to be softened by proper treatment, the exact method depending on the chemical analysis of the water in question.

High Load Factor Makes an Attractive Electric Load

High-pressure steam at boiler pressure (125—175 lb. gage) may be required for generating equipment, refrigeration machinery, pumps, and compressors. Hotels usually operate laundries and high-pressure steam at 100 lb. or more is required for this service. The kitchen

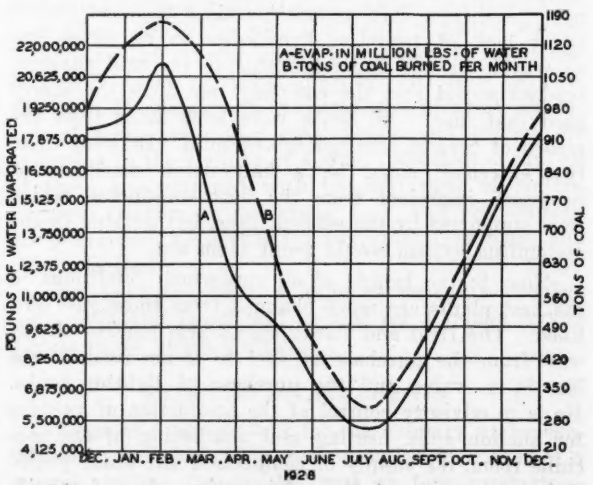


FIG. 1. CURVES FOR AN 1100-ROOM HOTEL SHOWING THE VARIATION IN MONTHLY EVAPORATION AND COAL BURNED

Karr Parker, of Buffalo, N. Y., manager and member of the firm of McCarty Bros. & Ford, is a native of Kentucky. He was educated in Illinois and holds the degrees of B.S. and D.Sc. from Carthage College and M.S. from the University of Illinois. Following graduation from Illinois, he was identified with the radio industry for three years in the employ of the United Western Wireless Telegraph Co. and the Marconi Wireless Telegraph Co.

In 1914, he entered the employ of McCarty Bros. & Ford, of Buffalo, as electrical engineer and was made manager and a member of the firm in 1918. In addition, he is consulting engineer for Hotels Statler Co., Inc., the United Gas & Electric Co. and others.

He is a member of the A. I. E. E., A. S. M. E., I. E. S. and past president of the Engineering Society of Buffalo.

TABLE I. TYPICAL MONTHLY POWER PLANT REPORT OF AN 1100-ROOM HOTEL

Current Purchased, kw.hr.	254,000
Sold to Tenants, kw.hr.	8,401
To Elevators, kw.hr.	19,516
Passenger Elevator, miles	4,414
Freight Elevator, miles	3,017
Kw.hr. per Car Miles	2.6
Total coal burned, lb.	917,900
Total coal purchased, lb.	1,102,800
Total steam to kitchen, lb.	1,488,190
Total steam to laundry, lb.	1,061,700
Total water evaporation, lb.	8,663,000
Average evap. per lb. of coal	9.5
Total consumption of water, gal.	13,967,000
Kitchen water, gal.	3,740,000
House water, gal.	7,977,400
Laundry water, gal.	2,249,600
Auxiliary kitchen gas, cu.ft.	235,600
Main kitchen, cu.ft.	228,300
Guest cafeteria, cu.ft.	65,100
Help's cafeteria, cu.ft.	20,300
Bake shop, cu.ft	142,300
Cakes of ice	596

equipment requires steam, which may be obtained from the high-pressure system through reducing valves, at pressure varying from 30 to 50 lb. Coal burned and evaporation month by month in an 1100-room hotel located in a northern city is shown in Fig. 1. This hotel purchases all electricity required from the public utility, consequently the steam load is largely a heating load with no generating apparatus involved.

Table I gives the quantities of electricity, steam, gas, coal and water and the relative demands of the various department required for one month's operation of this same hotel. A typical daily electric load curve for this house is shown in Fig. 2. The load factor of 72 per cent indicated is representative, as hotels operate 24 hr. a day and have a relatively high load factor. A hotel load is very attractive to the public utilities.

Purchased Power vs. Private Generation

Electric power may be purchased or generated while sometimes a combination of the two makes the most economical arrangement. If power is purchased, either alternating or direct current, and sometimes both, will be available. High tension alternating current (if available) will be at a lower rate but will usually require a capital expenditure for transformers, circuit breakers and equipment to convert the current to a voltage suitable for use in the hotel. The interest, depreciation and maintenance cost of this added equipment must be balanced against the saving in the power bills in order to determine the advisability of purchasing high or low tension alternating current rather than direct current.

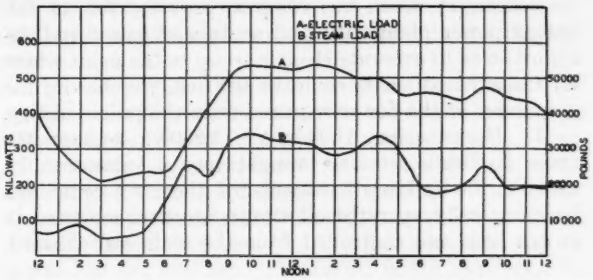


FIG. 2. TYPICAL DAILY ELECTRIC AND STEAM LOAD CURVES

After determining the quantities of steam and electricity required for a given hotel, the next problem is to design a power plant to supply these services in the most economical and reliable manner. Many factors enter into such a calculation; the cost of purchased power, the price of coal, space available for boilers and generating plant, labor conditions and similar items. The analysis of an actual problem, a new 1350-room hotel with attached office building with a total of fifteen million-cubic foot capacity, will be of interest and serve to illustrate the method of solving this problem. On referring to Table II, it will be seen that five schemes for supplying steam and electricity for this building were considered as follows:

		Annual Cost
Scheme A.	Purchased d.c. service	$154,250.00
Scheme C.	Purchased d.c. service with partrial d.c. generation	147,841.00
Scheme B.	Purchased high-tension a.c. service	149,997.00
Scheme E.	Complete d.c. or a.c. generation	137,765.00
Scheme D.	Purchased high-tension a.c. service with partial conversion to d.c. and partial d.c. generation	127,840.00

TABLE II. COMPARATIVE ANNUAL OPERATING COST ESTIMATES FOR A 1350-ROOM HOTEL POWER PLANT SHOWS CONSIDERABLE VARIATION

Scheme	A		B		C		D		E	
	Edison Service Direct Current No Power Gen.		Edison Service High Tension A.C. No Power Gen.		Edison Service Direct Current and Partial Generation		Edison Service High Tension A.C. and Partial Generation		Complete D. C. Power Plant Generation	
Item	Quantity Millions	Notes	Quantity Millions	Notes	Quantity Millions	Notes	Quantity Millions	Notes	Quantity Millions	Notes
1 Electricity consumption in kilowatt hours	4.2		4.4	5% for losses	3		3.15	5% for losses	4.4	Add.Vent
2 Kw.hr. generated in building					1.2		1.2		4.4	
3 Low pressure steam - heating, lb.	90		90		90		90		90	
4 Low pressure steam - ventilating	20		20		20		20		20	
5 Low pressure steam - hot water	45		45		45		45		45	
6 High pressure steam - kitchen and laundry	45		45		45		45		45	
7 Steam losses due to power generation					5	4#/kw.hr.	5	4#/kw.hr.	18	4#/kw.hr.
8 Waste exhaust steam									65	
9 Total steam required	200		200		205		205		283	
10 Pounds of coal at 8:1 - evaporation	25		25		25.62		25.62		35.375	
11 Tons of coal	12,500		12,500		12,810		12,810		17,687	
12 Cost of coal at $6.50 per ton	$81,250.		$81,250.		$83,265.		$83,265.		$114,965.	
13 Cost of electricity, approx.	73,000.		60,352.		57,626.		54,650.			
14 Scheme A, minimum installation cost										
15 Scheme B, transformers voltage reg. $30,000-10%			3,000.							
16 Scheme C, turbo generator $30,000-15%					4,500.					
17 Scheme D, gen. $30,000-equip.of"B" $60,000-15%							7,200.			
18 Scheme E, complete plant-add.boiler$100,000-18%									12,000.	
19 Add.water, waste, lubrication, etc.					1,000.		1,000.		4,000.	
20 Add.dynamo and boiler room labor					1,200.		1,200.		6,200.	
21 Value of space occupied - 50# sq.ft.			275.		250.		525.		600.	
22 Additional current for a.c. vari.speed motors			5,720.							
23										
24 Total	$154,250.		$150,597.		$147,841.		$147,840.		$137,765.	
25 Savings in a.c. instal.by cheaper a.c.motors $5,000-12%			600							
26 Comparative annual cost - Total	$154,250.		$149,997.		$147,841.		$147,840.		$137,765.	

Scheme D, which was adopted, provided for the following power plant with four sources of power and designed so as to generate electricity up to the point where all the exhaust steam could be utilized, purchasing the remainder of the power required from the public utility.

1. High-tension, 1500-kv-a., 13,800-v., 3-phase, 60-cycle duplicate services brought into a substation located in the building basement and there are controlled by electrically operated oil circuit breakers mounted in switch cells and controlled from the main switchboard.

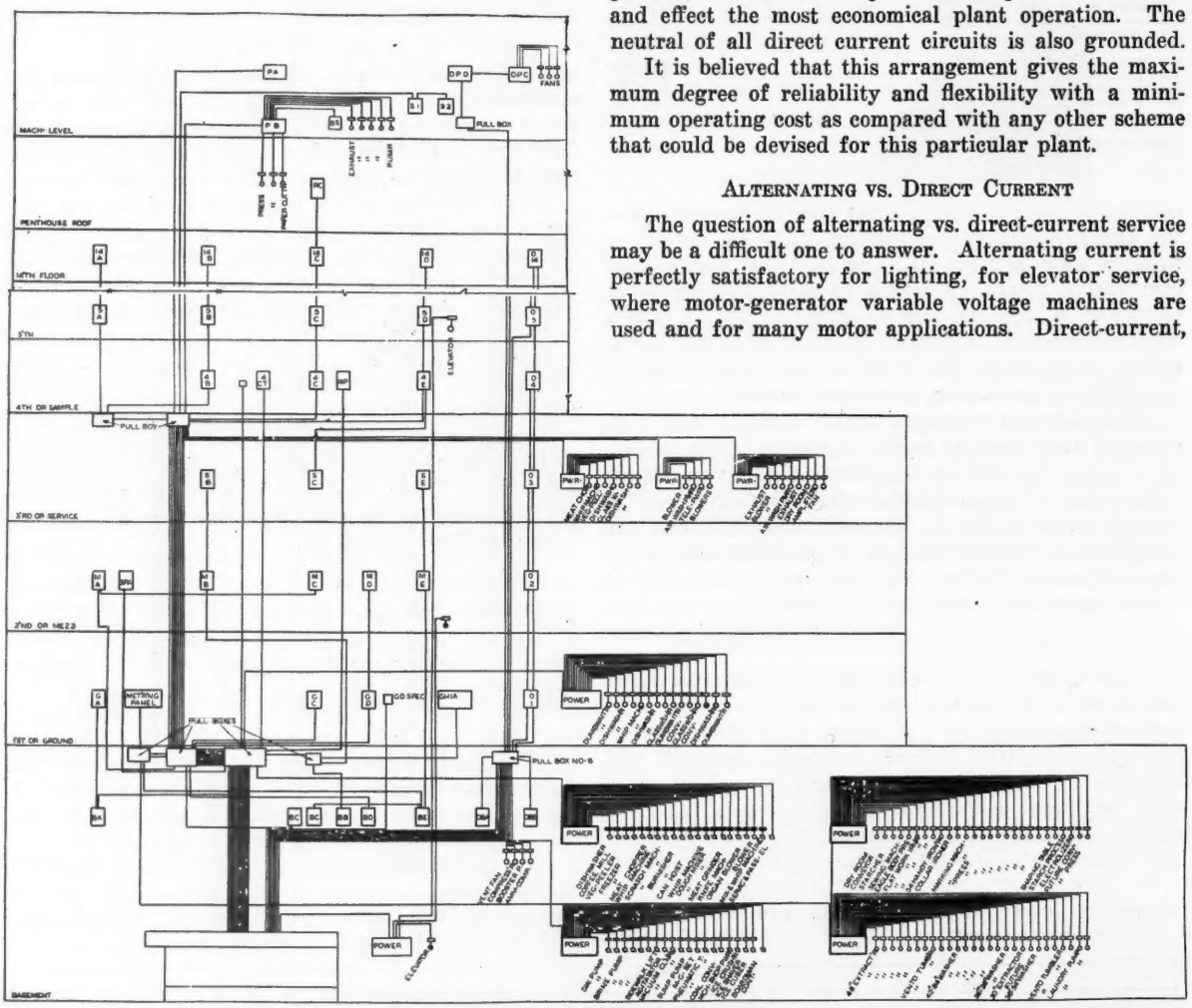


FIG. 3. ELECTRIC RISER DIAGRAM FOR A LARGE HOTEL SHOWING THE MANY SERVICES THAT MUST BE TAKEN CARE OF

A 500-kv-a., O.I.S.C., 13,800-t., 230-v., single-phase transformer with an automatic induction regulator on the secondary side of the transformer supplies three-wire, 230-115-v., single-phase, 60-cycle energy by means of a balance coil on the secondary. The neutral of this coil is grounded.

2. A 600-kw., 230-115-v., three-wire, emergency direct current supplied direct to the main switchboard.

3. A 500-kw. synchronous motor-generator set operating of the high-tension bus referred to above. The direct-current generator on this unit supplies 230-115-v., three-wire service to the main switchboard. This unit is started from the direct-current end by motoring the generator and synchronizing the alternating-current end with the incoming service. When the machine is properly paralleled and on the high tension bus, it functions to convert alternating current into direct current as required and may be paralleled with the two other sources of direct current.

4. A 750-kw. geared turbo-generator, Fig. 3, is installed, supplying 230-115-v., 3-wire, direct-current service. This unit is operated in the winter season at such times as its exhaust steam can be utilized. Its output will hold down the peak on the purchased service and effect the most economical plant operation. The neutral of all direct current circuits is also grounded.

It is believed that this arrangement gives the maximum degree of reliability and flexibility with a minimum operating cost as compared with any other scheme that could be devised for this particular plant.

Alternating vs. Direct Current

The question of alternating vs. direct-current service may be a difficult one to answer. Alternating current is perfectly satisfactory for lighting, for elevator service, where motor-generator variable voltage machines are used and for many motor applications. Direct-current, however, is to be preferred for variable speed motors such as required on ventilating fans and is absolutely necessary for the telautograph systems, moving picture and stage equipment, electric time stamp and clock systems, and various other signal systems required in a hotel.

A study of the losses in the controller resistances of wound-rotor, variable-speed alternating-current motors as compared with the shunt field rheostat losses in direct-current motors showed an annual resistor loss of $5720 for alternating-current motors in such applications as needed in the hotel illustrated in Table II. Alternating current is supplied wherever possible, how-

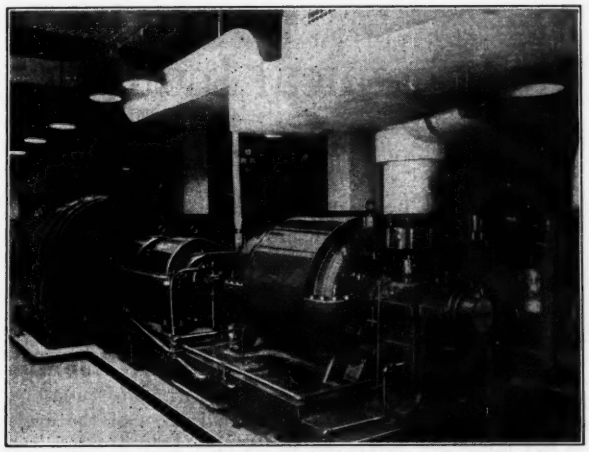


FIG. 4. MODERN HOTELS FIND TURBO-GENERATORS REQUIRE LITTLE SPACE. THIS IS A 750-KW. UNIT

ever, because its transformation loss is less. Direct current is supplied where necessary and in some cases both kinds of current may be used in a hotel, the alternating current for lighting and the direct current for power.

Elevators are an important factor in hotel service and are usually of the gearless traction type having a car speed of 600 ft. per min. in tall buildings. Each elevator, in the latest variable voltage design, is supplied by an individual motor-generator set, the armature of the generator being locked in circuit with the armature of the motor on the elevator machine in actual operation. The car speed is varied by changing the field excitation on the generator so that the currents which are handled by the controller are comparatively small. This gives smooth operation and reduces the resistance losses. Maintenance on controller contacts is reduced because no heavy currents are broken in this type of installation.

Automatic landing devices which automatically will land the car exactly at the floor level when the car switch is centered ahead of the floor are now available. Electrically-operated door openers may be provided for the hatchway doors on the elevators so that the door will open automatically when the car is in the landing zone.

In a large hotel, the ventilating load is a large proportion of the electric power requirements, averaging approximately 0.3 hp. per room. Fans are usually direct connected to low-speed, direct-current motors with speed regulation obtained by shunt-field control. The air in the public parts must be changed every few minutes, warmed in cold weather and in some cases cooled and washed in hot weather. The varied power requirements in a large hotel are shown in Fig. 4 an actual electric riser diagram.

One of the important services in a large modern hotel is the signal system. The transmission of orders to floor clerks and between various departments is usually done over the telautograph. Time stamps and recorders are necessary to the proper operation of the hotel and these devices must function at all times. A duplicate motor-generator equipment and storage batteries are usually installed for supplying the low-voltage fire alarm and signal systems.

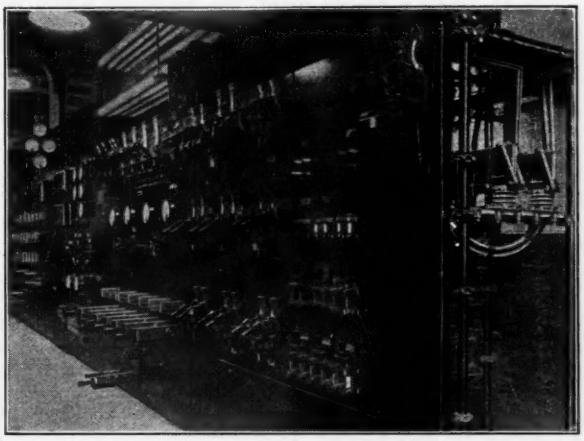


FIG. 6. IN LARGE HOTEL THE DISTRIBUTING SWITCHBOARD IS THE NERVE CENTER

In order to operate economically a hotel power plant complete and accurate logs should be kept with meter readings covering steam, water, gas and electricity consumption so that any inefficiency in operation can be promptly detected and corrected. The plant should be fully equipped with the necessary graphic meters and measuring devices to give the operating staff this data which they should use to keep the plant performance up to standard.

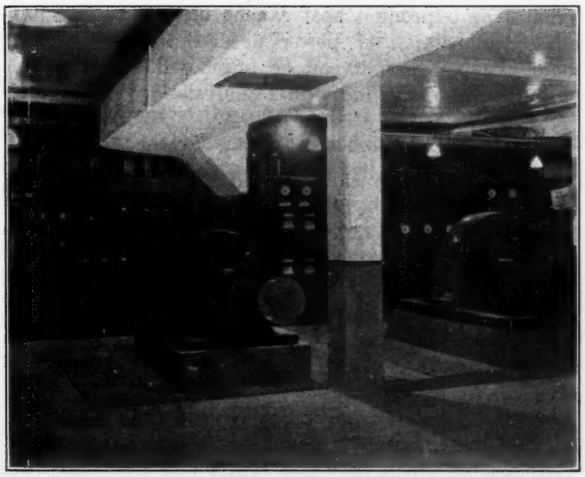


FIG. 5. A 1000-KW. SYNCHRONOUS ROTARY CONVERTER SUBSTATION IN AN ALL-ELECTRIC HOTEL PLANT

OF THE SEVERAL heat losses from a boiler furnace that carried away by the chimney gases is the largest and as a rule the easiest to reduce. This loss can be determined easily by means of a gas analysis and a temperature reading of the exit gases.

Low CO_2 may be the result of poor combustion but a low CO_2 and high O_2 indicates excess air which carries away a great deal of heat. High temperatures of the gases leaving the boiler or economizer also indicates heat losses which can often be reduced by redesigning the baffles. Often, high temperatures are the result of baffles burning out or slipping out of place.

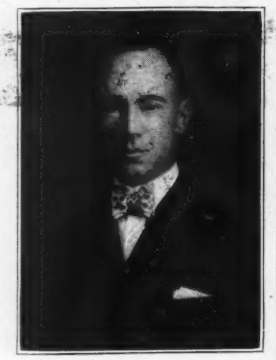
Power Requirements of the Chemical Industry

ENGINEERING SKILL PLUS STEAM POWER AND ELECTRICITY HAS ACCOMPLISHED WONDERS IN THE CHEMICAL INDUSTRY. BY W. A. HANLEY*

IN DEALING with the steam and power requirements of the chemical industry the subject must be treated broadly as the chemical field covers so many different kinds of industries, that generalities will find many exceptions.

Most chemical reactions or physical changes in the chemical industry involve either the addition or withdrawal of heat, so that most plants must have devices for adding and taking away heat. Heat ordinarily is supplied through the medium of either steam or electricity and is usually removed through the medium of cold water or refrigerating machinery.

In the ideal chemical plant, the materials would be unloaded, when received in car loads, by electrical machinery, conveyed by electrical conveyors and usually ground or pulverized by electrical driven grinders. Evaporations and concentrations would occur with steam as a heating medium, obtained as a by-product of the steam turbine in the power house, and both steam and electricity would be used in further processing or refining. Gravity, where possible, and conveyors otherwise should move the materials to their final destination on the shipping room floor.



WILLIAM A. HANLEY, Chief Engineer of Eli Lilly & Co., Indianapolis, Ind., is in charge of all engineering, construction, mechanical development and maintenance of this company and its subsidiaries.

He is a native of Indiana and following preparatory school he spent 5 yr. at Muncie, Ind., with the Republic Iron & Steel Co. and the Broderick Boiler Co. before attending Purdue University, from which he graduated in Mechanical Engineering in 1911.

Following graduation, he joined the staff of Eli Lilly & Co. and has been actively engaged with his associates in gaged with his associates in building up that business to its present proportions over a period of eighteen years.

Major efforts have been in the design and application of pharmaceutical and chemical machinery and appliances, development of straight line production, machinery and methods and industrial engineering as applied to manufacturing plants.

Among other activities, he is a member of the A. I. E. E., Director of the Indianapolis Smoke Prevention League and a Member of the Council of the A. S. M. E.

There are few chemical plants which do not need a power plant as a necessary adjunct. This does not necessarily mean that the chemical industry should generate all or even any of the electric power it uses. In most cases, however, when the heat balance of the industry is studied it is found that the requirements for steam and electricity are so related that one can usually be secured at low cost as a by-product of the other.

One large plant located near Chicago generates steam at 200 lb. pressure with about 100 deg. F. superheat. This steam is first used on process work, where it gives up the superheat, and becomes saturated at 150 lb. From here it is used on a turbine for driving an electric generator, the turbine being bled at the 5-lb. stage for steam for dry houses and for heating buildings. In the plant referred to, the steam performs three functions and all the heat units are made to work. Unfortunately, during the summer months the third stage of the cycle is not operative except as to the dry houses, since the buildings do not require heating in the summer months.

In another large chemical plant, manufacturing a similar line, the cycle is transposed; the steam is used first for power generation, second for high temperature processing and finally for low temperature heating.

STEAM AND ELECTRIC HEATING ELEMENTS ASSIST HEAT BALANCE

To the uninitiated, this cycle sounds perfect; in reality, it has many factors to be balanced. If the demand of the steam turbine, the process equipment and the low-pressure heating were equal, at all times of the day and night, winter and summer, the dream of the thermodynamist would be realized. Unfortunately, that never comes true.

Probably more than any other industry, the chemical industry gives to the engineer the possibility of making a heat cycle and balances which will be economical. This is true because the industry uses large quantities of both heat and electrical power, while certain other industries use a great deal of one and little of the other.

In studying his heat balance, the chemical engineer can often replace a steam heated process with an electrically heated process or vice versa, to make a better balance. The general rule for electrical power in the chemical industry is to make power in so far as the exhaust or byproduct heat can be utilized and to purchase the balance of power needed unless it can be made cheaper than it can be purchased. Each plant, of course, needs an individual analysis.

DEPENDABILITY IS IMPORTANT

While an economical heat balance should always be sought, it must not be obtained at a sacrifice of dependability. The first requirement of any industry in the chemical group is, that the supply of steam and electricity be unfailing. The cost of many chemicals is so great that their destruction or total loss, due to an interruption in process, would involve more money in a few hours than the economical heat balance would save in a year.

In the chemical group are usually included the paint, oil, dye, drug, explosive and heavy chemical industries. The uses to which they put steam and electricity are shown in a general way in the accompanying table.

In the chemical industry, where the equipment is

large and the lots worked are in hundreds of gallons or thousands of pounds, distillation processes are generally carried on with steam as the heating agent. There are some exceptions to this rule where heated oil, mercury, direct fired stills or electrically heated stills are used. These cases ordinarily fall into the high temperature class, higher than can be supplied with steam.

Direct fired stills often can be operated as cheap or cheaper than steam heated stills; but the advantage of temperature control, fire hazard, convenience of operation and safety are all with the steam heated still. Many stills are operated under a vacuum and in such cases exhaust steam on most products will furnish a cheap and satisfactory heating medium. In a plant with

Electrically Heated Elements Have Advantages

What has been said generally of the uses of the still and the mediums of supplying heat will be true largely of processes involving evaporating, concentrating and rectifying. Certain chemicals are so inflammable that no direct fired apparatus can be considered in any process where they are involved. Other chemicals are so sensitive to heat that only the most rigid care to avoid overheating will prevent their destruction. The apparatus, in each instance, must be selected to meet the particular requirements.

Where the apparatus is small and the process must operate for long periods without an attendant, electrically heated apparatus has a definite place and a

SOME OF THE MANY WAYS STEAM AND ELECTRIC POWER ARE USED IN THE CHEMICAL INDUSTRY

	Live Steam 100 to 300 lb. per sq. in.	Exhaust Steam 1 to 60 lb. per sq. in.	Electricity
As heating agent	Distillation	Distillation	Distillation
	Evaporation	Evaporation	Evaporation
	Concentration	Concentration	Concentration
	Rectifying	Rectifying	Rectifying
	Drying	Drying	Drying
	Sterilizing	Sterilizing	Sterilizing
	Washing	Washing	Washing
	Heating	Heating	Heating
In steam cylinders or turbines as mechanical power	Refrigerating machines		
	Compressing air		
	Pumping water		
	Generating electricity	Refrigerating machines	
		Generating electricity	
Power for driving			Refrigerating machines
			Compressing air
			Pumping water
			Conveying equipment
			Miscellaneous motors
			Solenoids
			Magnets
			Illumination
			Electric furnaces

which I am familiar, steam is generated at 130 lb. and is used at this pressure on all stills, requiring jacket temperatures of 300 deg. F. or over. On processes requiring temperatures of 212 deg. F. or over, but less than 300 deg. F., steam is used at 15 lb. pressure, having first been expanded from 130 to 15 lb. in driving large air compressors.

In processing requiring less than 212 deg. F., steam at 1 lb. pressure, exhausted from Corliss engines driving electric generators, is used. A live steam line, of course, must always make up the deficiency when the process line pressure is not maintained by the exhaust from the engines or air compressors. The reducing valves, which automatically supply the live steam, are so arranged that the 1-lb. exhaust line draws on the 15-lb. line for any deficiency, and the 15-lb. line in turn draws on the 130-lb. line. In this way, no live steam is used if there is a surplus of exhaust, at the pressure desired or at any higher pressure.

decided preference. Could the ordinary plant produce heat in the form of electric energy as cheap as they can produce it in the form of steam, there would be a tremendous change in our chemical industries and electrically heated equipment would largely replace steam heated equipment.

Drying in the chemical industry takes a great many forms, from ordinary atmospheric evaporation, where neither the time element nor the final water content is essential, to drying under the most precise conditions. Much drying is done under controlled conditions, where air is used as the drying medium and where the air is carefully conditioned as to temperature and humidity. Hit and miss drying with hit and miss results is decidedly unprofitable. In virtually all large dryers, producing conditioned air, steam is used as the heating medium because of the lower cost to produce heat in the form of steam.

In some instances, however, large electrically heated

dryers are being used economically. For work involving lots of 100 lb. or less, the electrical dryer has a decided preference, as it is relatively small, requires fewer connections and is somewhat simpler. Temperature regulation, where electricity is the heating medium, is easier of control than where steam is the heating medium.

Waste Heat Can Sometimes Be Utilized

Where mechanical separation or drying occurs by the centrifugal method both steam and electricity are used. The centrifuge may be driven by a steam turbine or by an electric motor. Each has its place, and each has advantages but the electric motor drive seems to be gaining in usage over the steam turbine. The moving parts of dryers, such as fans, pumps, conveyors and elevators are virtually all driven by electric motors. In large drying operations, such as removing moisture from coal, waste heat from power house chimneys is often used in preference to steam because it can be obtained cheaper. Electricity, under such circumstances, would obviously be prohibitive in cost.

Sterilizing ordinarily means raising the temperature to 240 deg. F. or over to kill bacteria. Both steam and electricity are used as heating mediums for this purpose. When dry sterilization is necessary, steam in closed coils or electrical heaters is used; but in wet sterilization, steam alone is the heating agent. Gas, of course, is another source of heat often used for sterilizing. Generally, however, except in small laboratory experimental apparatus, steam is used on large sterilizers and electricity on small ones, the latter being simpler but too costly to operate where large amounts of heat are required.

Steam Is Satisfactory Cleaner

Washing and cleaning in the chemical industry is a serious problem. Where apparatus is used for different products carelessness in washing or cleaning has cost many thousands of dollars. Contaminations, mixing of colors, acid and alkaline reactions have all taught the experienced that good hot steam, as a cleaning agent, has few equals and often is much preferable to powerful chemical solvents. For this reason steam in indispensable in most chemical plants for washing and cleaning and a considerable portion is used for that purpose.

Heaters in the chemical industry cover indeed a large field of apparatus. Buildings usually are heated by steam and in recent years the unit heater in the form of an electric fan back of an efficient steam radiator has found much usage in the chemical as well as other industries. This, of course, is but a simple adaptation of the blower system minus the air ducts. It is cheap to install, operate and maintain, takes little space and is decidedly efficient. It combines the cheapness of steam and the utility of electricity into a good heat dispensing machine for buildings.

Because of the large amount of piping and plumbing involved in most chemical plants, heating systems are required even where but few people are working. In some instances, however, where much heat is liberated by processes, the heating system finds its greatest use on Sundays and holidays. Small amounts of direct radiation still heat some chemical plants and are generally used where the least amount of air disturbance is desirable.

Chemical Industry Has Grown With Electrical Industry

Heating in processes covers a tremendous field and one in which both steam and electricity play important parts. Many chemical changes require high temperatures where direct combustion of gas, oil, coke or coal furnishes the most economical method. Processes requiring heat above 800 deg. F. practically always obtain such heat by the preceding method or by electricity. Seldom, if ever, is there such a process where electrical heat is not the most desirable. The higher cost, however, often prevents its use. With reduced costs of making electricity, the tendency for the electrical method will become more general. The applications for small electric heaters are so numerous that much could be written on this subject alone.

On a finishing belt, I have seen in a space of 10 ft., electrical heaters melting materials to be packaged, other electrical heaters keeping materials from congealing and still others heating glue pots and heating sealing machines. The small electrical heater was one of the greatest contributions the electrical industry ever gave the chemical industry. Probably the first two requirements of the chemical industry were heat and water. Before the days of electricity, they had steam power and before the days of steam power, there was animal and human power; but there was also very little chemical industry. Today, electricity is as indispensable as heat or water and its uses are constantly growing.

Refrigerating machinery is also necessary and important. The machines range in size from the small household unit to single units involving hundreds of tons. In every case, heat or mechanical power is involved. Both absorption and compression cycles are used. The small units are ordinarily of the compression type, using an electric motor for power, and in recent years small automatic absorption refrigerating machines, using the heat from a gas flame or the heat from an electric coil as the form of energy, have also been introduced. The processes involving large amounts of refrigeration use either the steam-driven or motor-driven compression machines or the absorption machine operating on low-pressure or exhaust steam.

Absorption Machines Often Work Into Heat Balance Nicely

Probably the industry as a whole uses more refrigerating capacity in the form of compression units. Much power either in the form of steam or electricity is used for this purpose and many ingenious combinations have been worked out to obtain economy. One large chemical plant, using Corliss engines for driving electric generators, uses the exhaust from these engines to operate large absorption refrigerating machines. These refrigerating machines are used for air conditioning where dehumidifying is involved and this dehumidifying is limited to the warmer months of the year.

In the colder months of the year, the exhaust from the engines is used for heating buildings. This is a decidedly economical plan, especially since the plant referred to is so located that water to run these engines condensing cannot be obtained. Another plant uses live steam for engine-driven ammonia compressors and takes the exhaust steam from these engines to operate at 2 lb.

pressure other refrigerating machines of the absorption type.

Compressed air is another of the necessities of the chemical industry. It seems to be used in abundance everywhere. In displacing liquids, lifting water from wells, cleaning, transferring materials, operating hoists, agitating and in many other ways, it plays an important part in the chemical industry. The air compressors are driven by steam or by electric motors. There are some exceptions but they are few in the chemical industry, where oil engines are driving electric generators, refrigerating machines or air compressors.

Air compressors, of course, are large and small for pressures of 15 to 150 lb. The writer has seen many instances where it was cheaper to install a small motor-driven air compressor in a remote building than to pipe air from the central power house. In some instances air is compressed at two different pressures, the lower pressure being used where it will suffice, and the higher pressure being used only where needed. This lower pressure is usually from 10 to 40 lb., and the higher pressure from 75 to 150 lb. per sq. in.

Few are the chemical plants which do not generate at least some of the electric power they consume. The generators are usually driven by turbines or where the industry is small Corliss or unaflow engines. Like all other industries, 110-v. d.c. was first used for both power and light. In the last 30 yr., direct current, both 110 and 220-v., has been replaced by alternating current; 60-cycle, 3-phase, 440-v. seems to be used more largely now than any other.

Newer Plants Favor Alternating Current

In certain large applications, involving electric furnaces, high voltage current and 25-cycle are used and in a few other instances, 2300-v., 3-phase, 60-cycle has been employed. Some plants still feel that 220-v. direct current is preferable for general use but the newer and more progressive have generally adopted alternating current. The reasons for this, of course, are not peculiar to the chemical industry but apply generally to most industries. The transmission of direct current is costly. Direct current motors are more expensive in original cost and in maintenance. Of course, the matter of power factor is not present with direct current. Neither is the question of heavy duty starting, while the matter of speed regulation is in favor of direct current.

The above have all been ably met by the manufacturers of alternating equipment with synchronous motors, squirrel cage motors, heavy starting duty motors and slip ring motors. Of course, the final answer to direct current is that if you want it you must make it or at least transform it yourself. It is not for sale to large industries.

About 5 yr. ago the writer changed over a plant from 110 v. d.c. to 440-v., 3-phase, 60-cycle for all motors ¾ hp. or larger and 110 v., single-phase, 60-cycle for motors under ¾ hp. This new plant had 1000 motors ranging from 125 hp. down to fractional hp. motors. Much pressure was brought to keep the job on direct current and the advantages of direct current were loudly proclaimed. The job was put through on alternating current, however, and every motor application was studied for type and size of motors and method of drive. The installation has been satisfactory, dependable, safe and economical, and has fully justified the decision in favor of alternating current.

The chemical industry has gone forward by leaps and bounds and was much stimulated by the World War. Science and research have in recent years discovered many new products, improved old products and brought to light great unknown truths so that the chemical industry has made more progress in the last 25 yr. than in the previous 100 yr.

Except in crude materials, the modern chemical plant has little resemblance to its forefather. Where formerly were dust, foul smells and dirty operators doing slavish work lifting and wheeling heavy loads, today we have the clean, well lighted and ventilated, conveyorized, mechanically operated institution. Power created for the use of man has been put to work. These things could not have been done if methods in the industry had not kept pace with the growth. In fact, methods by reducing costs have regularly preceded growth. These methods have usually consisted of engineering skill plus steam power and electricity and an abiding faith in the future of American industry.

Tests made many years ago by the Bureau of Mines showed that each per cent of dry ash in the coal reduced the effective heat value of the coal by one and one half per cent. This ash in coal comes from one of three sources: from the coal structure itself, from impurities in the coal seam, or from dirt and rock included in the process of mining.

It is the one factor over which mining companies can exercise control. Inherent ash comes from the woody substances of which the coal is composed. This cannot be controlled. The second two can be controlled by careful mining and preparation.

Ash content of coals are best compared on a dry basis, because, before the coal burns, the moisture evaporates, leaving the dry coal and ash. A certain coal might have a moisture content of 20 per cent and an ash content of 10 per cent. Before combustion takes place, the moisture is driven off, increasing the ash content 12.5 per cent of the dry coal.

When dividing the cost of steam production between electric power and process in an industrial plant, it is quite simple to base this division on the relative amount of heat used by the turbine. In other words, the amount of steam charged to the turbine bears the same ratio to the total steam flow to the turbine as the heat removed from this steam bears to the original steam.

With high back pressure turbines where the exhaust is dry, this division is a simple matter; but when bleeding, or when the exhaust is wet, the allowance should be made for the wetness of the steam which, in some cases, amounts to 10 per cent of the total flow. Cost accounting in cases of this kind is bound to be more or less arbitrary, because it is impractical to divide justly all investment, insurance and depression costs. Boiler plants designed for producing by-product power are higher pressure and cost more per unit of capacity than would plants to supply straight process steam.

Heat Energy and Power Uses in a Food Industry

ROASTING, BAKING, DRYING AND HANDLING GIVE WIDE SCOPE FOR DEVISING HEAT AND POWER ECONOMIES. BY H. W. BROWN AND P. P. PRATT*

PERHAPS NO DISCOVERY of mankind has ever surpassed in importance, that of fire. No agency of civilization is more tremendously destructive when abused; or more productive when harnessed to provide heat energy and power.

poration, speaking before the American Publishers' Association recently, awakened considerable interest when he stated that our national food bill was $23,000,000,000 annually, or 26 per cent of our total estimated national income.

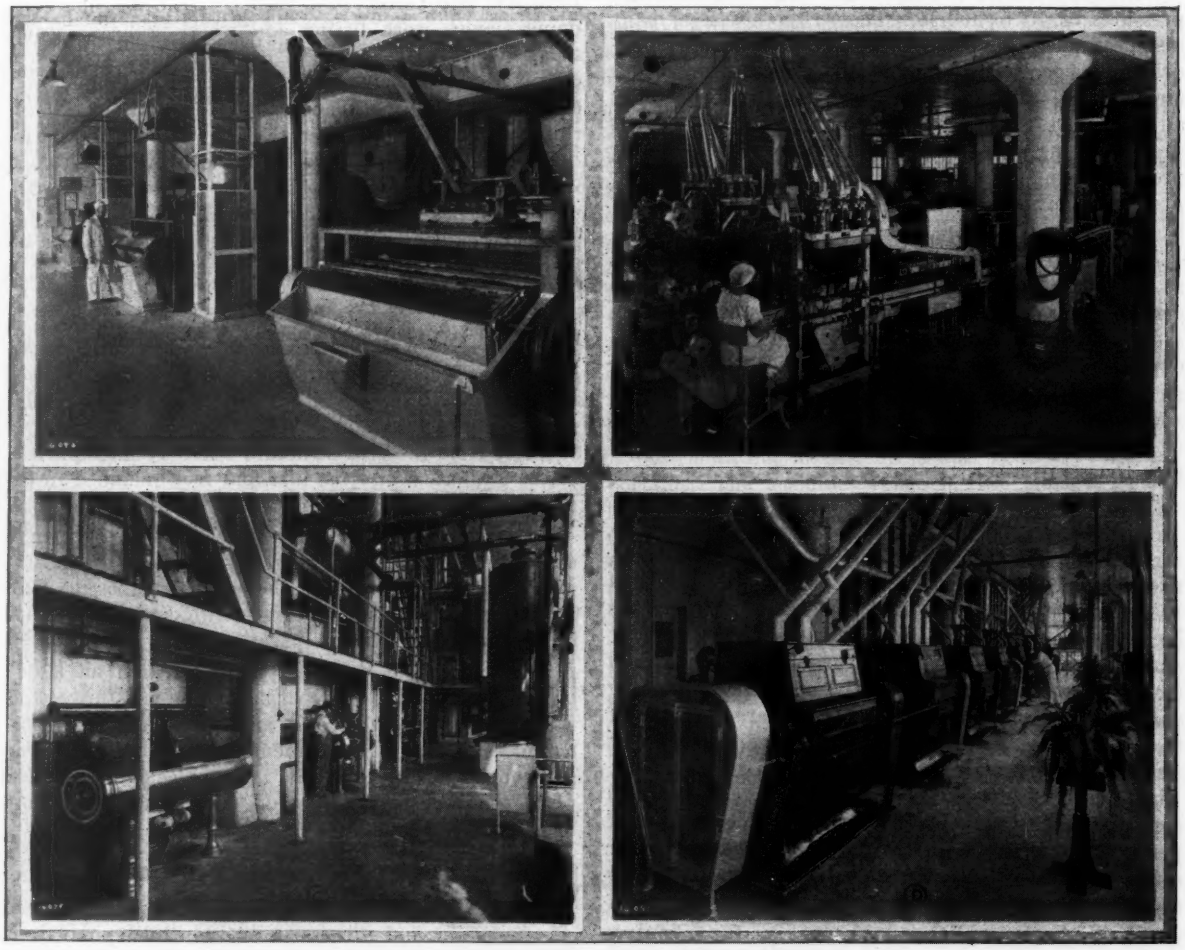


FIG. 1. A—GRAPE NUTS DRIED WITH AUTOMATIC HEAT REGULATION. B—PACKING WITH AUTOMATIC CONTROL OF PACKAGING HEAT AND POWER. C—PERCOLATORS AND EVAPORATORS FOR INSTANT POSTUM HAVE VACUUM AND TEMPERATURE AUTOMATICALLY REGULATED. D—FLOUR MILLING BY PARTIAL TEX-ROPE DRIVES HAS AUTOMATIC GRAIN CONTROL SWITCHES

One hesitates to think of our condition today if we were dependent upon man, animal or water for power; or of the importance and extent of civilization, if provided with only raw, fresh, or sundried foods. The primal instinct of man was to provide food, consequently our progress in other fields has improved remarkably since heat energy and power have assumed the burden of providing, preparing and preserving foods.

C. M. Chester, Jr., President of General Foods Cor-

For purposes of this writing, we are referring to heat and power as related to the Postum Co. which manufactures at its Battle Creek plant such well-known cereals as Grape-Nuts, Postum, Post Toasties and Bran Flakes. Discussion will cover power, steam, and gas application that may be of interest to readers of Power Plant Engineering.

Our problem is one of economic distribution and consumption, rather than generation, inasmuch as we are located near a dependable source of power. Our supply is 5000 v., transformed to 440 v. for power circuits, 220

*Battle Creek, Mich.

and 110 v. for lighting. Duplicate emergency circuits are maintained between our plant and the power source. In addition, another circuit for power and lights at critical points in our processes provides adequate protection against losses due to power failure.

Departments are metered to control distribution of load and power costs. The larger portion of our power load is induction motor and recent installation of capacitors on our circuits has brought attractive savings due to regulating and improving the power factor. Motors vary in size from ⅛ to 350 hp., the latter being a synchronous load.

Demand for power within our various departments is characteristic of all straight line processes, especially that of foods, where the interval of time between the raw material and cased product is necessarily uniform. Such a load requires dependable power for 24 hr. daily. Compensators serve to start and protect the great bulk of our load, while thermoload, time and special duty switches handle a smaller share, usually where multiple or remote control is desired.

Alternating-current power, comprising 90 per cent of our load, is used for the following classes of work: Material handling, storage and conveying, milling, grinding, rolling, drying, shredding, baking, roasting, toasting, blending, cooking, evaporating, cooling, mixing, warming, packaging, shipping.

Direct-current power is used for certain classes of work identified with the carton and case manufacturing division of our plant. Although variable speeds have been quite universally in demand for the following work, there is a gradual change to alternating-current power for crane service, paper pasters, case printing, carton printing, cutting and stitching, cutting and gluing.

Steam Is Used for Processing

Process steam is supplied at 125 lb. pressure by five, 500-hp. Stirling-type boilers, equipped with mechanical stokers, having the usual arrangement of auxiliary equipment and heaters, characteristic of a low-pressure steam plant. A close account is kept of boiler room operation with relation to evaporation per pound of fuel used, as well as cost per 1000 lb. of water evaporated. Process conditions within our works require approximately 25 per cent of makeup water treatment in boilers, as shown in the daily report form.

Bomb tests of each car of coal received are conducted at our control laboratory and the factor of evaporation is computed from schedules according to B.t.u. content. Coal is mechanically handled from car to storage or to bunker, thence to boilers, a reserve storage of approximately 10,000 t. being maintained for emergencies. Ashes are handled from boiler room to car on siding by vacuum conveyors.

Auxiliary steam load consists of air compressors, vacuum pumps, water pumps and fire pumps, the latter for high-pressure water. Air compressors and vacuum pumps are centrally located at the power house, as are also the steam-driven fire and water pumps. Motor-driven water pumps are located at wells throughout the plant to furnish artesian water that supplies the various processing departments. An idea of the depth of these wells and the character of the water may be gained from the knowledge that temperature does not vary over half a degree from 52½ deg. F. during the entire year and periodic tests have always shown the water to be unusually pure. Our pumping capacity is 3300 gal. per min. on all pumps, ordinary operation requiring 50 per cent of this capacity.

The principal steam load is devoted to manufacturing grains into cooked cereals, utilizing evaporation, driers, and cookers; an additional load is required for heating water, materials and buildings. A few economical applications which our power department has developed will be of interest to engineers.

Exhaust and Waste Heat Is Salvaged

Production of Instant Postum may be considered as a typical instance of studied heat economy. Roasted

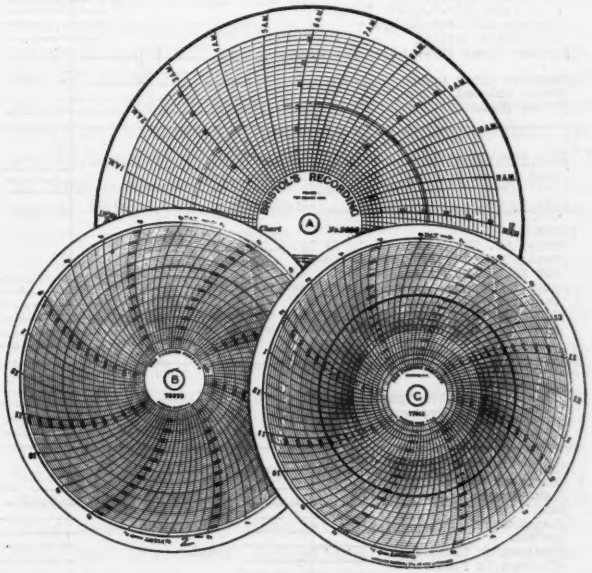


FIG. 2. A—PRESSURE REGULATION BY AUTOMATIC STEAM CONTROL. B—TEMPERATURE REGULATION WITH AUTOMATIC GAS CONTROL. C—AUTOMATIC TEMPERATURE CONTROL OF STEAM HEATING

grains, flavored with molasses syrup are percolated with an abundance of hot water; the extract is clarified to remove all insolubles, then evaporated to a thick syrup-like consistency, dried, ground and packaged for shipment. The former method required a large number of vacuum pumps for dryers and evaporators. By locating this equipment on the third floor of our building, we were able to maintain a constant vacuum with evacuators and eliminate all wet vacuum pumps for driers and evaporators.

Exhaust steam from these air ejectors supplies heat for a series of evaporators, capable of operating single, double or triple effect, and for heating our drum dryers. The remaining exhaust steam is used to maintain hot water for many uses in the process, and to yield low-pressure heat for the Instant Postum group of buildings.

Another conservation of heat energy should be mentioned, namely, that of drying a cereal residue or mash to make by-product feed and condensing the evaporate. Mash residue contains approximately 80 per cent moisture and is easily pumped to the dryer house. Roller presses reduce this moisture to approximately 68 per

cent, in which condition it is received by rotary steam dryers and dried to 12 per cent for use as cereal feed. The large amount of moisture evaporated in the dryers passes through surface condensers, all cooling water passing to hot water heaters, after absorbing considerable heat through the condensers. This is a valuable source of hot water and affords a splendid saving in heat energy for the manufactured product. At normal production, a very good heat balance is maintained in the Postum group of buildings.

Long, slow baking at moderate temperature is required by Grape-Nuts, thus allowing the conversion of grain starches to natural sugar. Heat plays an important role in governing the action of this process.

Foreman fill in items marked # DATE 192

BOILERS
#Rated B.H.P.Hours Fired Banked
% of Total B.H.P.Hours in Use
Average Load for 24 hr.
% of Mfgrs. Rating
#Boiler Hours Fired Since Cleaning (1) (2) (3) (4) (5) (6)
#Boilers Blown Down AM PM
#Water Columns Blown Down AM PM
#Tubes Blown AM PM
AM PM

COAL
#Total Lb. Coal Burned 24 Hr. Per Hr.
Coal Burned per sq.ft.Grate Surface per Hour
" " " " Water Htg. " " "
#Ash in Coal Per Cent Weight

WATER
#Total Lb. Water Metered in 24 hr.
#Water Used to Blow off Sludge
Net Lb. Water Evaporated 24 Hr. Per Hr.
Actual Evaporation per Lb. of Coal as Fired
Factor of Evaporation
Equivalent " per Lb. of Coal as Fired
Evaporation per sq.ft. Grate Surface per Hour
" " Water Htg. " " "
#Lb. of Make-up Water Used % of Total

#Average % of CO_2
" Feedwater Temperature
" Steam Pressure
" Flue Gas Temperature (1) (2) (3) (4) (5) (6)

LABOR	Man-hours	Cost	TOTAL COST
#Engineer			Cost of Coal Used at
#1st Fireman			" per net Ton
#2nd "			Cost of Labor
#Repairmen			
#Ashman			
#Coalmen on Bunkers			Total
#Coalmen in Field			
Total			Cost per 1000#Water Evaporated

#Maximum Load, 24 hours in kw.

Remarks

Signed

FIG. 3. POWER HOUSE REPORT

Steam as the heating medium, with forced air circulation in the continuous apron ovens, carries off an amount of moisture equal to half the dry weights of the finished product. Close control is obtained by dividing steam coils for each oven unit into sections with regulator on each.

Several similar instances of heat conservation could be cited but the fact remains that all Post Products are cooked and this condition requires drying before packaging; thus steam drying is important for it may be conservatively estimated to be 60 per cent of the factory heat load. Our dryers could be classified: (a) Steam heated air, forced circulation, gravity flow. (b) Steam heated air, forced circulation, mechanical flow. (c) Vacuum dryers. (d) Steam coil contact, gravity and mechanical flow.

Heat in lesser proportions is adapted to: (a) Product and building sterilization. (b) Oven and room conditioning for both moisture and heat. (c) Water heating. (d) Steam cleaning. (e) Heating materials to expedite handling. (f) Building heat.

Practically all conditions of steam heat energy require rather close control, hence we depend almost universally on automatic temperature and pressure controls. In one instance, our power engineers have developed a device, for automatically regulating temperature, air recirculation and humidity to govern a certain phase in the manufacture of flaked cereals, which has greatly improved the margin of quality and accomplished an attractive saving in steam.

Gas for Roasting and Toasting

Gas has two necessary characteristics for the food industry, combining the advantages of cleanliness with relatively high temperatures essential for roasting and toasting, thus replacing older methods of coal heat. Considerable study and experimentation is warranted with gas fuel, because wasted heat is an important item of expense. Usually, to justify additional costs for gas, improvements in food quality and reduction of food losses must be placed in the balance to offset increased heat costs.

In the initial process of both Cereal and Instant Postum, carefully roasted grains are prepared and blended to produce the cereal product. Gas heat is essential to maintain uniformly controlled roasting temperatures but more recently the roasting cost has been reduced with steam drying, which accomplishes the removal of considerable moisture before the roasting process is started. The net savings were quite attractive; moreover, the process time was cut in half and the complete roasting unit was capable of higher capacity, at more uniform quality.

Many years ago, gas heat replaced coal for toasting corn flakes. This field has remained unchanged for the last two decades, although economies have been effected to improve methods of heat application, with elimination of waste heat volumes. More efficient combustion mixtures of air and gas, as well as improved insulation and vent control, all react to reduce gas costs during the last decade.

Until recently, coke was the fuel used to bake Grape-nuts loaves. New developments in heat control, oven insulation and the use of continuous bake ovens have allowed an economical application of gas, greatly improving the quality of this product, as well as reducing waste.

Introduction of excess air in the front of the furnace has become almost standard practice with some forms of stokers, especially the chain grate. It is impossible to force sufficient air through a fuel bed to burn the coal completely. Gases arising from the front of the stoker are rich in hydrocarbons while that from the rear or burned out end are rich in oxygen. It is practically impossible to mix them quick enough to burn completely by means of arches or high velocities. Turbulence caused by the introduction of air jets in the front of the furnace brings the rich and lean gases together intimately and gives good combustion. They are especially effective for smoke prevention in poorly designed furnaces or where the boilers are being worked hard.

Laundry Use of Heat and Power

HOT-WATER DRYING AND MACHINE DRIVE GIVE OPPORTUNITY FOR STUDY OF HEAT BALANCE.

BY ANDREW A. BATO*

IN HARDLY any other industry are conditions as favorable for generating power in the plant and utilizing exhaust steam as in laundries. Due to the number of plants and their frequent contact, there exists a lively interchange of ideas and experiences resulting in a quick spreading of new and efficient methods.

Requirements of heat and power energy, classified according to the form in which they are applied, are as follows:

Live steam to heat machinery, such as steam mangles

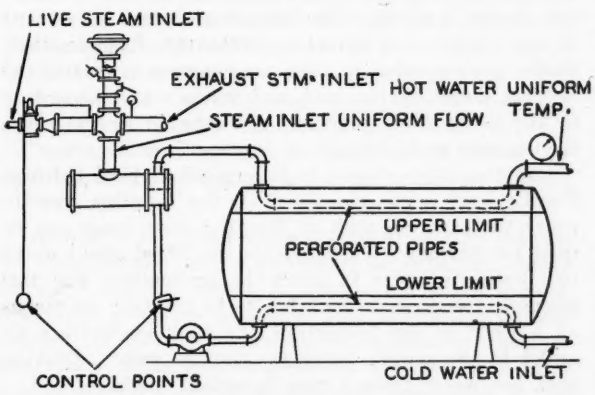


FIG. 1. STEAM HEATER USES EXHAUST AND LIVE STEAM TO CHARGE STORAGE TANK

or ironers, presses, stocking forms, drying tumblers, at a standard pressure of 100 lb.

Hot water to supply washing machines, at about 180 deg. F.

Driving power for ironers, presses, drying tumblers, washing machines, extractors or centrifugal dryers, also for conveyors, ventilators, elevators, and, in some plants, for charging the storage batteries of electric delivery trucks.

Many laundries are still using live steam to heat the water to higher temperatures right in the washing machines, instead of in the water heating tanks. This, however, is considered objectionable, because live steam is likely to break up the suds, or, when applied with the bleach, to damage the goods. For this reason, up-to-date plants have discarded the steam connections to the washing machines, or are using them in case of emergency only.

HOT WATER A DECIDING FACTOR

Hot water is used in laundries not only in great quantities, but at a temperature of 180 deg. F. or slightly less, which makes its production with exhaust steam at 3 to 5 lb. back pressure simple and efficient. Also, it is used practically continuously, as it has to be changed in every washing machine every 5 to 10 min. Furthermore, heat can be stored in hot water much more simply and at much lower cost than in steam. One cubic foot of tank capacity will store about four times as much heat in hot water as in steam, besides, the water pressure is usually much lower than the steam pressure and, finally, the regulating valves and other fixtures are much simpler in case of the hot-water tank.*

All these facts lead to the present condition of things, namely, that the great majority of laundries, large and small, ranging in boiler capacity from 50 hp. to much over 1000 hp. are generating their own mechanical or electrical power. In many cases, they install second-hand slide valve engines, of which there are many on the market. Economy of the engine until recently has been no factor, as all the exhaust steam could be used for generating hot water and some live steam had to be used in addition, that is the heat and power balance was very favorable.

Matters, however, are complicated from the point of view of the heat and power balance in two ways. First of all the temperature of the city or well water that is to be heated varies according to the season. Second, and this between much greater extremes, the nature of the load varies during every week. Washing is usually done during the first 2 to 4 days, especially where much of the wash is to be delivered as wet wash, that is unironed. Ironing and pressing are usually started late in the morning on Monday and continued often until Saturday noon. Consequently, during the early part of the week, the exhaust steam of the engine is insufficient to supply all the hot water required and some live steam is used in addition; while, towards the end of the week, it is common to see large amounts of exhaust steam puffed out through the exhaust head, because more driving power and less hot water are required. Exceptions are laundries that are kept busy throughout the week by giving towel-supply service or working for hospitals, hotels and other institutions which, in contrast to the housewife, accept the work on any day of the week.

STORING HOT WATER

Water is generally heated in a closed horizontal tank holding about one-half hour supply, with a bank of copper tubes in the tank connected to the exhaust of the engine and to live steam, the latter connection being controlled by a thermostatic valve. This method, however, is somewhat unsatisfactory, especially in cases where much live steam is to be added to the exhaust steam, as it may lead to variation of temperature of the hot water and of load on the boiler. To avoid these troubles, a system is now being installed, Fig. 1, consisting of a water heater with practically no storage capacity and a storage tank, the water being circulated between the two by a centrifugal pump, the cold water

*Consulting Engineer, East Orange, N. J.

*See author's discussion: Transactions of the A.S.M.E., Fuels and Steam Power, Vol. 50—No. 15, Page 78.

from the bottom of the tank to the heater and the hot water from the heater to the top of the tank. Steam consumption of the heater is continuous, the fluctuations of the load being taken up by the storage tank, in which the imaginary plane separating the hot water from the cold is going up or down according to whether more hot water is being generated than used, or vice-versa. Operation of the hot water heater stops only if the storage tank is filled with hot water down to the bottom, in which case a thermostat stops the pump and cuts off the steam.

Days in which the economy of the steam engine was of no importance, as the exhaust steam could be all used for generating hot water, are, however, coming to an end. The factors bringing about this change are as follows:

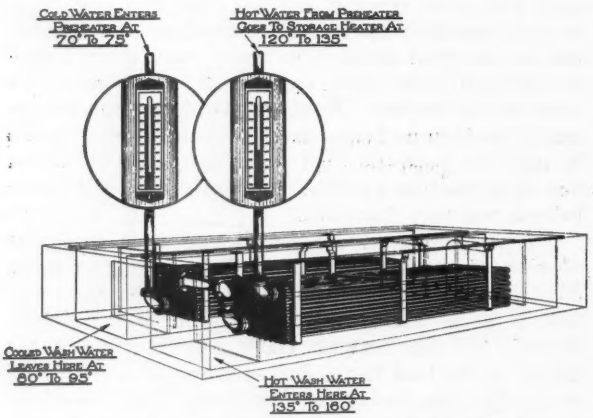

Cold Water Enters Preheater At 70° To 75°
Hot Water From Preheater Goes To Storage Heater At 120° To 135°
Cooled Wash Water Leaves Here At 80° To 85°
Hot Wash Water Enters Here At 135° To 160°

FIG. 2. DIRTY HEAT UNITS ARE RECLAIMED

First of all, in the past the laundries did a great amount of wet-wash or damp-wash, that is the goods were washed, only, then dried in an extractor and delivered without being ironed or finished in any other way. In some districts, laundries are still doing nothing but wet wash but many laundries produce a greater or less high percentage of finished, that is ironed work, with quite a number doing 100 per cent finished. More finished work means more driving power for the finishing machinery, with no additional use of hot water, that is of exhaust steam. The trend in the market is an increasing proportional demand for finished work.

Second, conveying machinery is installed to an increasing extent, especially in laundries occupying multiple story buildings, as is the case with plants located in large cities where property is valuable. Likewise ventilation requires an increasing amount of power. Laundry machinery, both washing and finishing, produces heat and vapor to an extent which the management, the working personnel, and the authorities are unwilling to endure.

The final blow to uneconomical power generation, however, was given by the advent of the heat reclaimer, commonly called preheater, a heat exchanger using the heat contained in the dirty, soapy warm water discharged from the washing machines to preheat the cold clean water coming from the city line or well, before it enters the hot water heating tank. The principle of utilizing this form of waste heat is old and not a specialty of the laundry industry. The requirements to be met by the heat exchanger are, however, such as do not exist in any other line.

Discharge from the washing machines has three qualities which make its use difficult. One is the content of soap, soda, and dirt which forms a scum and covers the cold heater tubes with a film, hindering the conduction of heat. Another is the content of lint, which clogs narrow passages and covers the tubes. This lint is unavoidable, wherever clothes are handled which are not entirely new. Finally, the organic matter removed from the goods through the solvent effect of soap and soda will develop a fermentation causing a most unpleasant odor and unsanitary conditions. For these reasons besides that of high efficiency, one of the first requirements in a heat reclaimer is accessibility.

Heat reclaimers now in most general use consist of a concrete tank in the floor into which all the discharge of the washing machines flows, Fig. 2. A set of U-shaped horizontal copper tubes is located in the tank, with the ends of the tubes connected to one or more box shaped headers. The cold clean water enters one of the headers and leaves it, preheated, from another. Baffles are provided in both the concrete tank and the headers directing the cold and warm water according to the counterflow principle. Discharge water leaves the concrete tank through an overflow into the sewer.

Another type of heat reclaimer has vertical U-tubes. Planks level with the floor of the laundry usually cover the concrete tank so that the floor space can be used for passage. These boards are lifted about every two weeks in order to clean the preheater. For this purpose, the concrete tank has to be emptied, by means of a plug at the bottom of the tank controlling an outlet to the sewer. Once the tank is empty, flushing with hot water from a hose is usually sufficient.

Ejectors Used to Advantage

If the level of the street sewer is too high, special provision has to be made for emptying the tank. Pumps have not proved quite satisfactory, as they usually become clogged with the lint accumulated during the time between cleanings. The same would happen to screens, protecting the suction ends of pumps. So far, the best results have been obtained with steam ejectors which can handle this liquid satisfactorily. Ordinary ejectors, with the steam jet in the center and the water flowing through the annular section around the jet, get clogged easily, hence it is advisable to use injectors in which the passage is free for the water and the steam is admitted through an annular nozzle surrounding the narrowest section of the Venturi tube.

Another type of heat reclaimer consists of a vertical cylindrical tank through which the clean cold water flows and which contains a number of tubes, like a vertical tubular boiler, for the flow of the warm dirty water. This tank, too, is located in a larger tank under the floor. The advantages of this system are that the tubes can be cleaned with brushes, and that there a greater volume of preheated water is stored.

Quite recently, heat exchangers are being tried similar to those used in other industries, that is built like surface condensers, in several sections, supported alongside a wall. The warm dirty water has to be pumped through the tubes and the results so far obtained seem to show, that, while it is practically impossible to pump

the concentrated lint content left in the tank by the water flowing through it, it is feasible to pump the lint with the water as it comes from the wash-wheel. One important point still to be cleared up in connection with this type of heat reclaimer is the time element. The washing machines at irregular intervals dump large quantities of warm water, which are likely to be pumped quickly through the heat reclaimer and have too little time to give up their heat content.

Purchased Power Sometimes Advisable

Significance of the preheater and its effect on the heat and power balance can be seen from the following brief calculation: The yearly average temperature of the cold water is about 50 deg. F., while the temperature to which it is to be heated is 180 deg. F. Consequently 130 B.t.u. are necessary to heat every pound of water. With the aid of the preheater, the temperature of the cold water is raised to about 95 deg. F., so that steam is needed to heat the water only from this temperature to 180 deg., that is to impart 85 B.t.u. to every pound. This is 35 per cent less than the 130 B.t.u. given above. As the heat needed to generate hot water is about 70 to 80 per cent of the total heat used in a 100 per cent finished work laundry, the saving in the total coal bill will amount to about 25 per cent, which shows the significance of the heat reclaimer for both heat balance and savings.

Advent of the heat reclaimer pointed sharply towards the installation of prime movers of the greatest possible economy and the result is that today many plants, especially new ones of larger size, are using uniflow engines. On the other hand, there are laundry engineers who vision steam turbo-generators, operated at a pressure of several hundred pounds with steam bled at 100 lb. for the ironers, presses and tumblers. Although this scheme has been considered in several instances, as far as is known, it has not been carried out.

In spite of the favorable conditions for the generation of power in the plant, the purchase of electric power may be warranted. In small plants, the price of a uniflow engine is prohibitive, especially as second hand units of this type are scarce. The slide valve engine is too wasteful to be used in combination with the preheater, thus the owner of the plant has to renounce either the saving through generating his own power or that offered by the preheater. Of the two, the greater saving is usually from generating power in the plant. Although the smaller engine unit is wasteful, this is overcome by the utilization of the exhaust steam. Besides rates for electric current are higher for the small consumer. On the other hand, the difference between the wages of a fireman and an engineer-fireman means more in the small plant than in the large one. Besides, in many cases, a fireman is working in some part of the laundry adjoining the boiler room, especially where oil burning is practiced. As a result, many small and even medium sized laundries are now purchasing power.

Power Transmission

Belt drive, electric group drive and individual electric drive are competing in the laundry as in other industries. The atmosphere of the laundry is not favorable for belts, which, with other evident reasons, brings about a victory for the individual electric drive.

In general, the application of electric driving power shows no particularities, except in driving the washing machines and drying tumblers. The moving part of these machines is the drum containing the clothes, which revolves at a moderate speed in one direction and, after 10 to 12 revolutions, according to the size of the machine, changes and revolves in the opposite direction for the same length of time, reversing repeatedly. This continuous change requires, not only a reversible motor built so as to work efficiently under the continuously changing load, but also an automatic control for reversing the motor at the right times.

Two systems of control fulfil this requirement, the one centralized and the other provided for each individual washing machine. In the centralized system, a small pilot motor on a panel board, which also supports the switches and fuses, drives a shaft at a geared down speed of one revolution for every complete reversal cycle of the washing machine. The vertical shaft carries a pair of copper segments for each motor, each segment subdivided into two parts, which slide on stationary contact fingers. These fingers have connections to the fields of the motors, arranged in such a manner that every change of segment on the contacts reverses the field current and with it the sense of rotation of the washing machine motor.

Electric Load Increasing

In case of individual control, the motor driving the washing machine itself imparts the motion to the reversing mechanism. Once the motor is reversed, it starts the reversing mechanism in the opposite direction, resulting in another change of connections back to the first sense. Change in the direction of the field current is instantaneous and is brought about while the motor is still running in the direction corresponding to the previous connection. This method requires especially designed motors to resist the frequent full-voltage reversing of current, which occurs every 8 to 10 seconds; also the reversing has to take place gradually, that is the starting or reversing torque must start low and increase with the speed. Motors with high reactance have proved to be good for this service.

Another problem of power transmission peculiar to laundries is the operation of the presses for shirts, and other finished pieces. Lifting of the upper part of the press, which moves on hinges, is done with a steam-driven piston, by compressed air, or in a few cases by electricity. The steam drive, although cheap in installation, is being eliminated on account of its wastefulness in operation and the compressed air drive is coming more and more into the foreground. Compressed air tanks supplied by either steam or electric-driven compressors are being used, with the electric drive gaining in popularity. Steam-driven compressors use much steam, a circumstance that was unobjectionable as long as all the exhaust steam could be utilized for generating hot water. Towards the end of the week, however, when most of the washing has been done but the presses are still in full operation, this exhaust is wasted to a great extent, for which reason the electric drive is resorted to. The introduction of the heat reclaimer is another point in favor of the latter.

Power and Heat to Finish *MILADY'S SILKS*

Unit costs for dyeing and finishing in two mills one purchasing, the other generating power. By J. G. Berger*

AS ONE THINKS of this vast activity in the manufacturing world, one becomes aware of many a process and differing raw materials as the basis for keeping the wheels turning.

Regarding one material, such as silk, wool, cotton or rayon, or, for that matter, with respect to one operation, such as carding, throwing, weaving, tin weighting, bleaching, printing, scouring, dyeing, finishing, an instructive book might be written but to limit this article so that it will permit the reader to get a glimpse of one small part of this tremendous industry, it will be confined to the piece dyeing and finishing of silks. These may be, all silk, or they may have as part of the weave, cotton, rayon or wool.

Finishing starts with piece goods received from the weaver, the silk containing much of the natural gums found in cocoons of the bombyx mori commonly known as the cultivated silk worm. The silk has already been reeled off, the cocoons, passed through the throwster's hands, possibly in the form of organizine for the warp or tram for the filling provided it is dyed in the skein, or just as yarn in the natural color for weaving. It also has gone through the weave shed where one of several methods has been employed to produce the piece of goods received by the finisher. The piece goods are now received by the dyeing and finishing plant which is the process with which this article deals.

Heat Starts the Finishing Process

First, goods are degummed by boiling off in hot soapy water, heat being applied by blowing steam into the water.

If the goods are all silk, the piece goods are then ready for weighting with salts of tin dissolved in muriatic acid, a process used for much of the all-silk goods manufactured. Weighting, which it is claimed weakens silk, can readily be detected by burning a piece of the goods. "Pure silk burns with a smell like burning feathers, leaves practically no ash, and forms a little gummy bulb where it leaves off burning. Weighted silk smoulders like punk and leaves a red gritty ash." So says W. D. Darby in the New York Dry Goods Economist.

If the goods that were degummed in the boil-off are mixed weaves containing cotton or rayon for example, they are next scoured, a process similar to rubbing goods together as in the old family washing methods, only it is now done by agitation in tubs of hot soapy water mechanically operated and for a short period.

After the boil-off and scouring, if required, the goods are sometimes bleached. Printing is also part of this process.

Dyeing Is Done Hot

Dyeing is done in vats, the water and dyes being cold at the start of the process but, by introducing steam directly into them, boiling temperatures are obtained which help set the colors, on much the same principle as steaming printed goods to set the color. Reels keep the piece goods continually moving through the dyeing liquid until it has assumed an even color. A revolving extractor or centrifugal now removes as much surplus moisture as possible and the piece is then stretched out on a tentering machine where dry heat (often gas flame) is applied to complete the drying and add to the lustre. Should it be desired to give the silk a rustle when worn in a garment, it is soaked, before the drying process, in acetic acid.

Silks dyed without weighting are known as pure dye silks. Mordants consisting of salts of tin or iron are used quite commonly for black silks. The mordant is a substance which has an affinity for both the fiber and the dyestuff, consequently is much used in dyeing cotton which is not so easily impregnated as silk.

Finishing Requires Both Heat and Power

After the dyeing process, finishing is the next step, calendering the cloth by passing between rollers being the usual process. Here steam is applied if a high lustre is desired, satins for example requiring heat. Many special methods are used to obtain the desired results. For example fuzzy silks are passed through gas bunsen burners or over heated electric plates to singe off the unnecessary fuzz. Also if silks are dampened, folded and pressed between hot calender rollers a water mark or what is known as a moiré-effect is obtained. By using engraved rollers various effects can be obtained.

After all finishing has been completed, the silk is tentered to stretch it to its original or a desired width. Inspection and packing for shipment completes the process.

Economy Requires a Heat-Power Balance

One realizes that the various processes discussed require much electric power, steam and gas. Low-pressure steam can be used in the early part of the process but for dyeing a higher pressure, namely 60 lb. or more of steam is required.

Nowadays there are great possibilities with 350 lb. and higher pressure boilers in new mills to generate the electric current required in turbines or steam engines

*Consulting Engineer, Newark, N. J.

that serve merely as reducing valves operating at a back pressure of 100 lb. to supply steam of sufficiently high pressures for all process purposes, with only 10 to 15 per cent of the heat taken from the steam for power generation purposes.

Where the boilers cannot operate at more than say 150 lb. gage, extraction turbines will often work out favorably for the generation of the electric current, though with reasonably low rates from the local central station, purchased power may be used, or a heat balance might prove favorable. In this last method, only power enough is generated to produce the steam for processes, any excess amount of power required being purchased. As a rule, in this industry little or no exhaust is wasted, even if all the power is generated.

It is the purpose of this article not to consider the relative merits of the various methods of generating or purchasing power, steam or gas for heat, but rather what the requirements of these commodities may be in silk dyeing and finishing.

Two mills are, therefore reviewed, one in which 1000 pieces a day of 60 to 80 yd. per piece are finished; the other larger and whose production covers a wider range.

To Finish 70,000 Yd. a Day

This mill finishes various kinds of goods, operates all processes except tin weighting and printing, and has averaged an output of about 1000 pieces a day, about 70 yd. each for 300 days a year.

Statistics from this mill, which is modern in many respects, will furnish unit quantities and unit costs of considerable interest for the designer of a new mill.

For twelve months or 300 days, 1000 × 70 × 300 = 21,000,000 yd. total output. Bituminous coal, of about 13,800 B.t.u., delivered in the bin, costs $1.90 at the mine, $3.22 freight and 65c delivery into bin, or $5.77 a ton.

Electric current and gas are both purchased, prices being 93.3 cents per 1000 cu. ft. and 2.88 cents per kilowatt-hour and the record being as follows:

Month	Coal in lb.	Kw-hr.	Cost	Gas cu. ft	Cost
January	1,015,200	20,760	$ 605.90	583,600	$ 566.24
February	902,000	29,760	806.06	796,000	757.40
March	957,000	31,320	848.46	770,400	734.36
April	798,000	29,160	811.98	693,600	665.24
May	648,000	20,760	628.30	673,200	646.88
June	578,000	21,480	644.94	692,000	663.80
July	558,000	23,520	696.94	617,600	528.03
August	618,000	22,920	667.02	608,600	520.83
September	599,000	27,480	785.10	681,400	579.07
October	*600,000	*20,000	*607.00	*700,000	*670.00
November	666,000	18,720	547.18	*700,000	*670.00
December	720,000	18,240	542.04	673,000	646.70
	8,659,200	284,120	$8,190.92	8,189,400	$7,648.55

*All figures marked are approximate, the balance are actual.

Yearly coal consumption is, therefore, 4329.6 t., which at $5.77 costs $24,981,792 or nearly $24,982.00. At an assumed average evaporation of 9.5 lb. of water per pound of coal the steam produced for the year was 82,262,400 lb. and cost of coal per 1000 lb. of steam 30.4 cents.

Unit costs per 1000 yd. of piece goods finished in this mill during a typical year, would be as follows:

Kw-hr. per 1000 yd	13.5
Cost of electricity per 1000 yd., cents	39.0
Cu. ft. of gas per 1000 yd	390.0
Cost of gas per 1000 yd., cents	36.4
Lb. of coal per 1000 yd	412.3
Cost of coal per 1000 yd	$1.19
Lb. of steam per 1000 yd	3917.2

Power Generated by Process Steam

This mill has a production of approximately 1½ times that of mill No. 1 and includes in its operations all those of mill No. 1 plus a greater amount of bleaching and considerable printing but no tin weighting. As the printing and increased bleaching together take practically three times the steam and power of the processes included in mill No. 1, some of the resulting figures obtained here should be divided by four in order to compare them with the same figures in the first mill. If coal is to be compared, the difference in heat value must be taken into account and allowance made for the fact that coal is used in this mill for generating current.

Recently this mill has gone over to pulverized coal obtaining evaporations of about 11.6 lb. of water per pound of coal with a 13,365-B.t.u. coal, although part of its load is carried on the old stoker-fired boilers. Probably the average evaporation of the entire plant is around 10.0 to 10.5 lb. of water per pound of coal as fired.

In the following records, however, this evaporation cannot be used for they are of a period prior to this improvement when the plant was operating on a combination of hand and stoker-fired boilers, using a mixture of anthracite river coal, anthracite mine coal and bituminous coal of an inferior grade. The three coals averaged as used about 10,000 B.t.u. and the evaporation under test was about 7 lb. of water per pound of coal.

Statistics of this mill, which is quite modern, are as follows and from them, unit costs are again developed which will prove of interest to the designer of a new mill.

Total goods finished during twelve months, 29,532,000 yd., or for 300 days, 1406.3 70-yd. pieces a day, average. Approximately 80 per cent of the goods is bleached and printed. Coal costs are approximately as follows, all being delivered prices: Anthracite river coal, $2.50; anthracite mine coal, $2.86; bituminous coal, $3.20; average heating value of mixture used, 10,000 B.t.u.

Gas is purchased but electric current and steam are produced in a power plant on the premises.

Consumptions by months are as follows:

Month	Coal in Tons Anthracite River	Anthracite Mine	Bituminous	Kw-hr.	Lb. of Steam	Water for Process in cu. ft.
Aug.	2660		300	160,200	36,485,000	70,835,000
Sept.	2673		308	158,600	36,233,000	60,954,000
Oct.	3030		316	184,200	38,976,000	62,859,000
Nov.	3164		390	181,000	39,833,000	60,572,000
Dec.	4360		476	203,000	45,703,000	60,776,000
Jan.	4505		659	181,200	54,456,000	69,222,000
Feb.	4596		560	182,000	58,857,000	77,460,000
Mar.	2343	2000	611	199,600	50,000,000	75,590,000
Apr.	1248	1500	221	161,000	37,096,000	50,506,000
May	1235	1700	122	126,900	33,624,000	49,970,000
June		2195	163	116,400	32,614,000	51,901,000
July		2470	263	156,800	34,120,000	43,634,000
	29,814	9865	4389	2,010,900	497,997,000	734,279,000

Gas used during the year was 24,122,500 cu. ft. at $1.25 per 1000 or a cost of gas for one year of $30,153.

Coal used in lb. (29,814 + 9865 + 4389) × 2000 = 88,136,000 lb. which, at an evaporation of 7, gives total steam of 616,952,000 lb. Cost of coal was $2.50 × 29,814 = $74,535.00 plus, $2.86 × 9865 = $28,213.90 plus, $3.20 × 4389 = $14,044.80, or a total cost of coal for one year of about $116,793.70.

From the foregoing, the following unit costs per 1000 yd. of goods finished have been developed.

Kw-hr. per 1000 yd	68.1
Cu. ft. of gas	816.8
Lb. of 10,000-B.t.u. coal per 1000 yd	2984.4
Equivalent lb. of 13,800-B.t.u. coal by direct ratio of the heat units per 1000 yd	2162.6
Lb. of steam per 1000 yd	20,890.9
Cu. ft. of water used per 1000 yd	24,863.8
Cost of coal per 1000 yd	$3.955
Cost of gas per 1000 yd	$1.021

Comparisons

To compare mill No. 2 with mill No. 1, due allowance for differences must be made.

Suppose we take the kw-hr. per 1000 yd. of piece goods finished which, in mill No. 2, is 68.1 while in mill No. 1, it is 13.5. These figures cannot be compared, as they stand because the printing and additional bleaching in mill No. 2 as electric and steam demands show, takes three times the power taken by the other operations which both mills have in common. Therefore, one-quarter of 68.1, or 17.0, compares with 13.5. The difference would probably be found to be less, if the two mills were tested department by department over long periods and results averaged.

In comparing the 2162.6 lb. of coal per 1000 yd. of piece goods of mill No. 2 with 412.3 lb. of coal of same B.t.u. value in mill No. 1, one must not only take one-fourth for reasons previously stated but 1/6 of the steam is used in condensing units and 1/6 is used as exhaust for process in which 20 per cent of the heat is lost. From this about 16.7 per cent plus 3.3 per cent or 20 per cent must be deducted for steam used for power only and the depletion and other losses of the exhaust used in the process.

Hence (2162.6 ÷ 4) × 0.8 = 432.52 which is within the range of 412.3 lb. in mill No. 1.

In a similar manner, the steam for comparison should be divided by four and multiplied by 0.8 or (20,890.9 ÷ 4) × 0.8 = 4178.18 which is close enough to 3912.5 for comparison.

The quantity of gas is a variable depending on methods employed. The reason why twice as much gas is used in the second mill as compared with the first can no doubt be explained in an involved analysis. Just to touch on this subject, one can readily see that the amount of fuzzy goods and velvets as compared with the total would seriously affect the gas required.

Miscellaneous Unit Quantities

It is generally rather difficult to segregate uses of steam and electricity in a silk dyeing and finishing plant and single values obtained here and there do not always seem to fit into the whole, unless one knows in detail relative quantities of the various kinds of piece goods dyed and finished.

Although they do not exactly agree with the ratio of four to one above used, the following figures are representative of what departmental testing may reveal:

Operation	Lb. of Steam per 1000 yd.	Kw-hr. per 1000 yd.
Boil-off	440.0	4.1
Dyeing	4700.0	3.9
Finishing	600.0	12.5

Conclusion

It is thus disclosed that an intelligent analysis of existing costs and requirements in any mill becomes a yard-stick for comparison with other mills and indicates quite plainly in what direction engineering effort may be applied most advantageously, namely where one may obtain the greatest return with the least investment.

Census Bureau to Cooperate With Industry

AFTER STUDY and consultation with the Advisory Committee on Manufactures, headed by L. S. Horner, president of Niles-Bement-Pond Co., plans have been made for a series of conferences with manufacturers and chambers of commerce throughout the country to facilitate the receipt of prompt and accurate returns to the Census Bureau and early issue of census reports.

John E. Palmer has been appointed as an expert on manufactures and distribution and will supervise the coöperative activities. At the industrial center of each of 17 districts conferences of delegates from organizations and firms in that district will be held to spread the knowledge of the value of business statistics and emphasize the importance of making accurate returns quickly so that census reports may be sent out early and in form to be of greatest use to local communities. Already conferences have been held in New York on Nov. 22, in Philadelphia, Nov. 25, in Atlanta, Nov. 27. Conferences to come will be as follows, at luncheon meetings:

November 29, Statler Hotel, Detroit; November 30, Hotel Statler, Buffalo; December 2, Hotel William Penn, Pittsburgh; December 4, Statler Hotel, Cleveland; December 5, La Salle Hotel, Chicago; December 7, St. Charles Hotel, New Orleans; December 9, Jefferson Hotel, Dallas; December 11, Statler Hotel, St. Louis; December 12, Fontenelle Hotel, Omaha; December 14, Brown-Palace Hotel, Denver; December 17, Olympic Hotel, Seattle; December 19, Claremont Hotel, San Francisco; December 20, Los Angeles Biltmore, Los Angeles; January 4, Boston Chamber of Commerce, Boston.

Delegates will be asked to keep their local papers informed of developments in census work, to organize meetings of local manufacturers in January and of distributors in April so that all executives may appreciate the assistance that the Census Bureau is endeavoring to give to industry.

Results sought are the availability to the Bureau of reports on production by the middle of February and of production figures to the industries within six months. Saving to the government is expected also in reduction of field work necessary to obtain correct reports.

Heat-Power Balance in Plant Serving Rayon Mill

Method of Calculating Steam and Power Costs Applicable in Plants Using Process Steam at Various Pressures. By Harry J. Kuljian*

INDUSTRIAL POWER PLANTS of efficient design are becoming more common on account of many small industries forming into one large organization, in order to compete with other large organizations and reduce their overhead charges to a minimum.

Although in many cases purchased power is most economical because of the relative steam and power

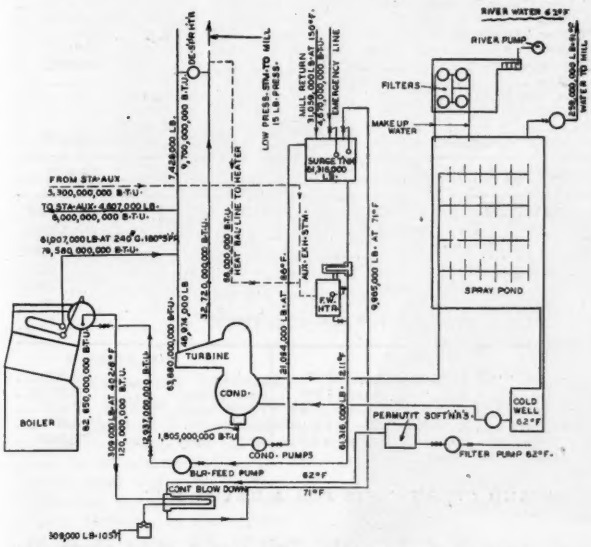


FIG. 1. HEAT FLOW DIAGRAM IN RAYON PLANT

requirements, there are industries which should generate their own electricity at any cost on account of the necessity of uninterrupted electric energy for their particular process. The rayon industry is one of those processes that require a constant voltage and frequency without any interruption whatsoever. A small amount of surge or variation in the voltage on the supply line would mean a great loss due to the non-uniformity of their product.

Steam and electric load requirements of some industries are, with the exception of the heating load, the same for summer and winter and other industries are different. There are processes that may require just sufficient amount of steam to generate electricity and give low-pressure steam for process work. To meet the requirements of a plant of this nature, there is always a question of what portion of the steam generated is chargeable to electricity. Of course, if the turbine runs condensing, the quantity of steam going into the turbine could be metered and this amount charged against the power generated.

In extraction turbines, since part of the steam goes into the condenser and part of it is discharged into the extraction line at certain stages of the turbine, the question arises as to what part of the steam going into the turbine is chargeable to the mill for process work.

*Engineer in charge of Power Division, The Viscose Co.

For economical purposes, most industrial plants install boilers designed for a higher pressure than they actually need for the process and heating system, and install pressure reducing valves to reduce the steam from high to low pressure in order to be able to use it for process work. When saturated steam goes through a reducing valve, it is superheated at the low pressure, a condition which interferes with the sensitivity of the heat transmission in the heat exchangers. To maintain the saturated condition at the reduced pressure, will necessitate the installation of a desuperheater. This is an added expense but it is the best way to take the superheat out of steam. If the plant is large enough, or its electrical and steam requirements are properly balanced, low-pressure exhaust steam can be secured from the turbine generating electric power, thus doing away with all pressure reducing valves in the plant, the repair and maintenance of which is comparatively high.

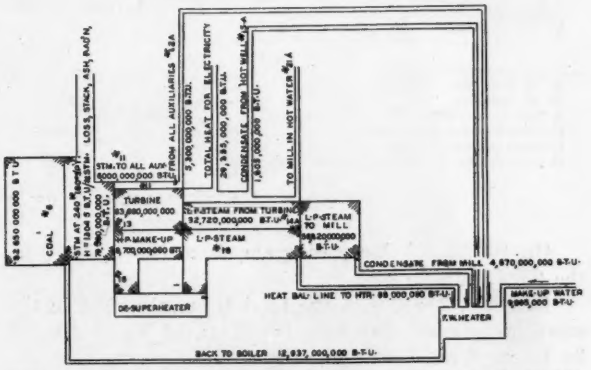


FIG. 2. GRAPHIC REPRESENTATION OF HEAT FLOW CALCULATED FROM MONTHLY REPORT

In back-pressure turbines, the quantity of steam in pounds that goes into the turbine is just the same as the quantity of low-pressure steam coming out of the turbine. In extraction type turbines, the quantity of steam going into the throttle of the turbine is divided into two parts. The first part is extracted at certain stages of the turbine and the remainder will go through the last stage of the turbine into the condenser. From the foregoing conditions, it is evident that it is not only the number of pounds of steam with which we are dealing but it is also the quantity of B.t.u.'s in a given pound of steam. In a plant serving a rayon mill, the method outlined here has been found to be a simple way of apportioning these charges.

Methods of Proportioning Costs

On the monthly report sheet, an assumption is made that the quantity of steam used in the power house and boiler house auxiliaries is divided into equal parts, 50 per cent being chargeable to the power house and 50 per cent to the boiler house. The condenser cooling water is also used in the mill for process work.

THE VISCOSE CO.

POWER HOUSE No. ____ PLANT ____ MONTH ____ 19__

STEAM GENERATION

1 Water to Boilers	61 316 000	Lbs.
2 Water Blown down #8 x Cp/Cb	309 000	"
3 Water Evaporated to 240 #gage 180 °sp. ht.	61 007 000	"
3A B.T.U. of #3 1304.5	79 580 000 000	B.T.U.
4 Factor of Evaporation (H_1-ht)/970.4 11.3	11.1	
5 Water Evaporated F. & A. 212° per Lb. of Coal #4x#3/#6		Lbs.
6 Amount of Coal Fired (3025 Tons) or	6 050 000	"
7 B.T.U. per Lb. of Coal Fired	13 150	B.T.U.
8 Make-up Water to Boilers	9 965 000	Lbs.
9 Make-up % of Evaporation #8/#3	16.15%	"
10 Boiler Hse. Efficiency [(H_1-ht)x#3]/(#6x#7) 80.7		
11 Steam to All Auxiliaries 240 #g. 180 °sp. ht. {50% B.H. / 50% P.H.}	4 607 000	Lbs.
12 Exh. Steam from Auxiliaries 1 #g. 0 °sp. ht.	4 607 000	"
12A B.T.U. of #12 1152	5 307 000 000	B.T.U.
12B Equivalent H.P. Steam of #12A = #12A/H_1	4 066 000	Lbs.

STEAM FOR ELECTRICITY

13 Steam to Turbines 240 #g. 180 °sp. ht. (H_1 = 1304.5	48 974 000	Lbs.
13A B.T.U. of #13	63 886 000 000	B.T.U.
14 Extraction from turbines 15 #g. 20 °sp. ht. (H_2 = 1173.0	27 880 000	Lbs.
14A B.T.U. of #14 1173.6	32 720 000 000	B.T.U.
14B Equivalent H.P. Steam of #14A = #14A/H_1	25 080 000	Lbs.
15 No. of Lbs. of Steam Condensing = #13 — #14	21 094 000	Lbs.
15A B.T.U. of # 15 @ " of Vac = qx#15	1 805 000 000	B.T.U.
15B Equivalent H.P. Steam of #15A = #15A/H_1	1 384 000	Lbs.
16 Total Steam for Elec. = ½ (#11—#12B) + #13 — [#14B + #15B + #21B]	16 480 000	Lbs.
17% of Total Evaporation = #16/#3	27%	Lbs.

STEAM & WATER TO MILL

18 High Press. Make-up to Mill 240 #g. 180 °sp. ht.	7 426 000	Lbs.
19 Total Steam to Mill (#3 — #16)	44 527 000	"
20 Water to Mill	259 000 000	"
21 Avg. Temp. Rise from River Water to Water to Mill	29	°F.
21A B.T.U. of #21	8 091 000 000	B.T.U.
21B Equivalent H.P. Steam of #21A = 21A/H_1	6 202 000	Lbs.
22 Avg. River Water Temp.	62	°F.

ELECTRICITY

23 100 Cycle Gen. @ % P.F.	645000	
24 60 Cycle Gen. @ % P.F.	1 707000	
25 Total Gen. = (#23 + #24)	2 352000	
26 Power Used for Station Aux.	282000	
27 Power Delivered to Mill = (#25 — #26)	2070000	
28 Power for Sta. Aux. in % of Tot. Gen. #26/#25	12%	

COST OF STEAM

29 Fixed Charges Boiler House	$	4,383.00
30 Coal 3025 Tons @ 4.27 Delivered	$	12 926.75
31 Coal Handling	$	
32 Coal Shrinkage in Stock	$	583.00
33 Labor Attendants	$	1 339.07
34 Labor R. & M.	$	1 015.83
35 Materials R. & M.	$	567.57
36 Water	$	
37 Oil	$	56.40
38 Supplies	$	
39	$	
40 TOTAL	$	20871.62
41 COST OF STEAM PER 1000 LBS.	$	0.343

COST OF ELECTRICITY

42 Fixed Charges Po. Ho.	$	4924.00
43 Steam	$	2 516.08
44 Labor Attendants	$	1 546.76
45 Labor R. & M.	$	538.57
46 Materials	$	488.05
47 Water	$	
48 Oil	$	
49 Supplies	$	
50	$	
51 TOTAL TO GENERATE	$	10 013.46
52 COST PER K.W.H. GEN.	$	0.426

53 COST R&M STOKERS PER TON COAL FIRED		.032
54 PREHEATERS		.027
55 BOILERS		.046
56 PIPING		.027
57 MISC. EQUIP.		.033
58		
59 TOTAL BLR HSE R&M PER TON COAL FIRED		.165

LEGEND

H_1 = Heat of High Press. Steam	1304.5
H_2 = Heat of Low Press. Steam (15A)	1173.6
q = Heat of Liquid at Certain Vacuum	88
Cp = Concentration in Permutit Water in P.P.M.	80
Cb = Concentration in Blow Down in P.P.M.	2500
ht = Temp. of Feed Water	211

COAL ANALYSIS

Moisture	3.63
Fixed Carbon	66.87
Volatile Matter	19.92
Sulphur	1.44
B.T.U. Content	13 860

FIG. 3. TYPICAL MONTHLY REPORT OF POWER AND STEAM COSTS FOR A RAYON MILL

On the heat balance diagram, Item No. 6 will give the total B.t.u. in coal.

Item No. 3 will give the total B.t.u. absorbed in the steam generated, therefore, the B.t.u. of No. 3 divided by B.t.u. of No. 6 will give the total boiler efficiency for that particular month.

Of the amount of steam that goes into the turbine to generate electricity, a certain part comes into the extraction main at 15 lb. pressure. The amount of steam that goes into the auxiliaries, one-half of which is chargeable only to electricity, is also returned back into the feedwater heater at 5 lb. pressure through a pressure reducing valve to heat the feedwater. A certain amount of steam that goes into the condenser is also returned back into the feedwater heater at a certain temperature and a certain amount of the heat in the circulating water, which has passed through the condenser, is recovered in the mill, therefore it will make the total steam chargeable for electricity as shown by item No. 16 on the report sheet.

Item No. 16 and the total amount of steam chargeable to the mill is equal to the total amount of steam generated, minus the total steam for electricity, which is shown in item No. 19 on the report sheet.

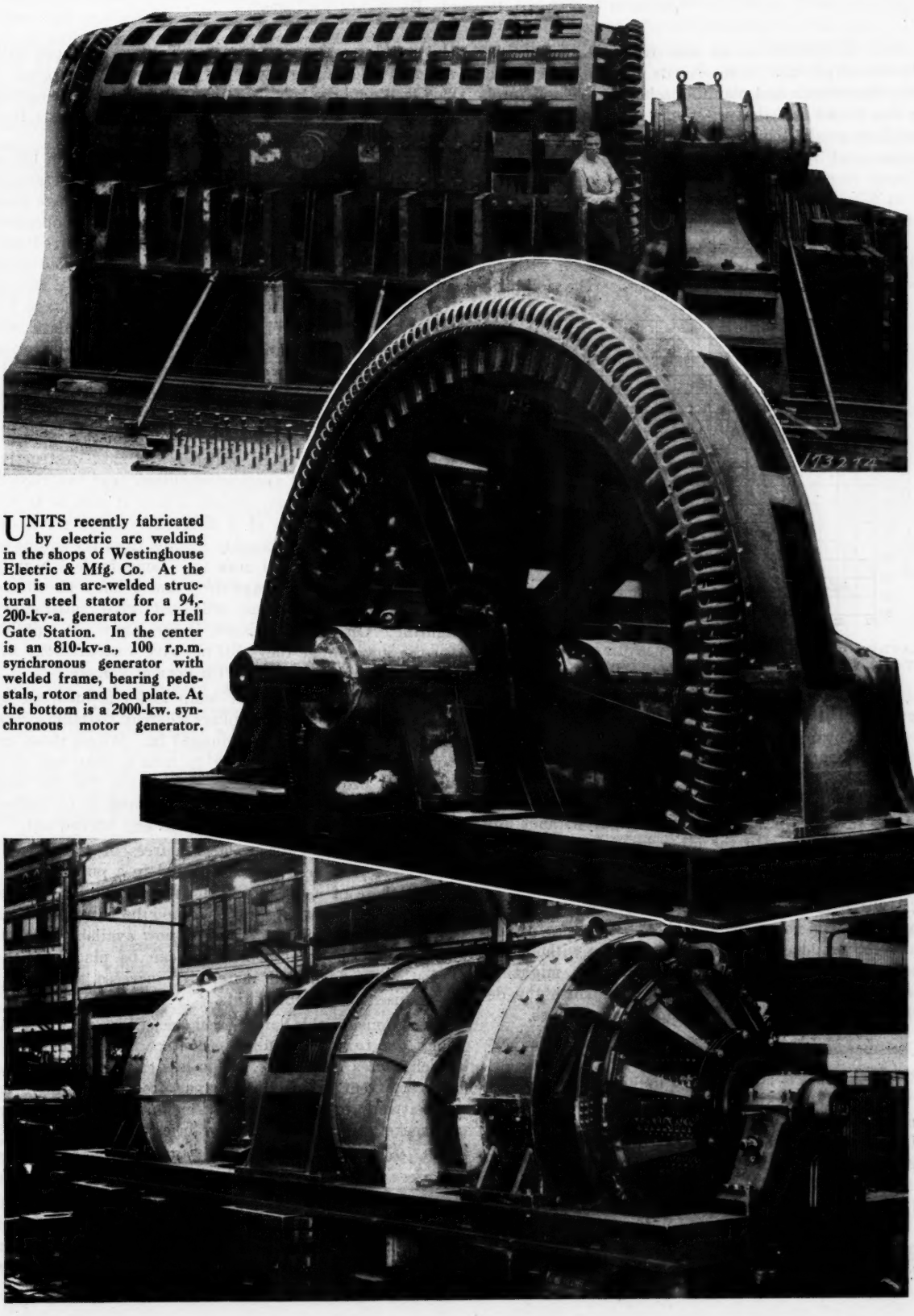
The cost of steam per thousand pounds and the cost of electricity per kilowatt-hour generated are shown in Items Nos. 41 and 52 respectively.

Item No. 59 will show the repair and maintenance in the boiler house per pound of coal fired and a space at the bottom of the report sheet gives the average chemical analysis of the coal. This report sheet shows the cost of electricity generated to be extremely reasonable on account of our high steam demand in the plant throughout the summer and winter.

HANDLING OF THE WORTHLESS ash through the various steps in the distribution and utilization of coal is a large item in the cost of energy delivered at the power plant, says the United States Bureau of Mines, Department of Commerce, in a recently issued bulletin. The principal cost factors increased by handling of excessive ash are: Freight; unloading and delivery cost; storage; conveying and firing; grate and furnace capacity, and ash disposal. For example, 1 per cent of excess ash in a 50-ton car of coal amounts to 1000 lb. of worthless material per car and entails a loss in transportation cost of $1 per car where the freight rate is $2 per ton. If an average freight rate of $2.40 per ton on the annual production of bituminous coal in the United States during 1927 be assumed, the transportation loss amounts to a total of $12,426,000 for each 1 per cent of unnecessary ash. Consideration of this one item alone shows the economic importance of dirt in coal.

PRACTICAL ELECTROMAGNETS were made in 1831 by Faraday in England and by Joseph Henry in America. Henry shares with Faraday the honor of discovering the laws of electro-magnetic induction.

Large Electrical Machines Fabricated by WELDING

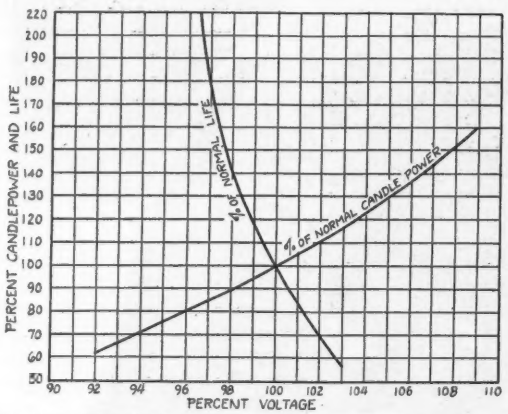


UNITS recently fabricated by electric arc welding in the shops of Westinghouse Electric & Mfg. Co. At the top is an arc-welded structural steel stator for a 94,200-kv-a. generator for Hell Gate Station. In the center is an 810-kv-a., 100 r.p.m. synchronous generator with welded frame, bearing pedestals, rotor and bed plate. At the bottom is a 2000-kw. synchronous motor generator.

Reducing Lamp Costs by Proper Maintenance

SUGGESTIONS FOR CUTTING THE ITEM OF LAMP EXPENSE IN INDUSTRIAL PLANTS. BY MARIN PHILLIPS*

LAMP EXPENSE in an industrial plant is an item that often fails to receive its proper share of the plant maintenance and planning schedule. This is probably due to the fact that the total lamp expense for the plant is a small item compared with the many other expenses and with this thought prevailing there is a tendency to overlook the lamp expenses. Nevertheless $40 to $75 a month cut from the lamp expense is a worth-while item. It is possible to save this amount in the average size plant if the lamp expenses have been neglected and not given the proper attention with the view in mind to lower the expenses. The following



RELATION BETWEEN OPERATING VOLTAGE AND RESULTANT LAMP LIFE AND CANDLE POWER OF INCANDESCENT LAMPS

suggestions will be of value to anyone who is desirous of cutting down on their lamp expenses.

1. Substitute a large lamp for small ones wherever possible. Sometimes it is possible to substitute a 100 or 200-watt lamp with a reflector, to replace two or three 100-watt lamps in a drop cord light without any kind of a reflector. On the other hand, places will be found where a smaller light will serve the same purpose as a larger one now in use.

2. Often more light is desired on a machine or in a location that is not properly lighted. In a case of this nature, the tendency is to add more lights without due consideration to the existing lights which might be moved, raised or lowered slightly and furnish the desired light without the addition of any new ones.

CONSIDERATION OF REFLECTED LIGHT FROM WALLS

3. Sometimes it is possible to paint a room properly and clean the windows or add another one and save on the expenses connected with the addition of more lamps.

4. Some places where lamps are subjected to considerable abuse and where the lighting requirements are not so particular, the old rugged carbon lamp can be used to an advantage. As an example of such a place, in a paper mill the pulp stock is stored in tanks under the machine and beater rooms, which are equipped with a sight pipe through which a drop light is lowered or raised to note the height of the tank contents. A carbon light serves this purpose very nicely and outlasts four of the modern small lamps in this service.

5. Another very important bearing on lamp life is the operating voltage. The life of a lamp is materially decreased when it is operated at a higher voltage than it was designed for. On the other hand, if it is operated at a lower voltage its lighting qualities will be reduced. Often abnormal voltage conditions will be revealed when an investigation is made. It is advisable to use a recording voltmeter and obtain a record of the voltage for 24 hr. in the different departments. This data will serve another important funetion as a guide in selecting the lamps of proper voltage for the plant.

In making a study of this kind, the recording meter should be left on over Sunday, when the plant is down, and often it will show that the voltage fluctuates over a wide range, mostly high, which is the most destructive on lamp life. Still another condition that the recording voltage survey may reveal is that it will be to advantage to use lamps of a different voltage for a department that is considerably distant from the source of supply than those used near by. Long feeders heavily loaded will have a voltage drop and a lamp purchased for the normal voltage will not give satisfactory lighting. On the other hand, if the lamps are suitable for the low voltage they will not give a satisfactory life in the other departments with normal voltage.

6. A serious source of lamp losses is incurred by the failure to provide wall plugs whereby portable lights, electric drills, etc., can be plugged in. Where these are not provided, it is necessary to take a lamp out of a socket to provide a place of connection for the tool. Often the lamp will be left lying around to be broken or gathered up and thrown away as one burned out.

7. Portable lights are also sources of considerable lamp loss. No lamp should be used in a portable light except those of a very rugged nature designed for the purpose. All portable lights should be equipped with a suitable lamp guard. There is now available a small inexpensive shock absorber that can be placed in the socket and which will materially increase the life of lamps used in portable lights.

8. Considerable lamp breakage occurs in wet locations, due to water coming in contact with the hot bulb which causes it to crack. This loss can be overcome to a great extent by installing vapor proof lights but even then it may be necessary to keep under sized bulbs in the sockets to prevent breakage in extremely wet places.

9. Sometimes it will be necessary to provide a stronger type of lamp guard than those in general use to prevent lamp breakage. It is sometimes possible to protect a row of lamps with a guard made of wire such as is used for making safety guards for machinery.

10. Among the greatest enemies of lamp life is

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vibration. Vibration is caused in a number of ways. In industrial plants vibration is often caused by the dropping of materials and trucking over floors which have lights installed underneath. Continual vibration is also transmitted to the lamps by moving machinery. There are now effective shock absorbers on the market which will prolong the life of lamps considerably where they are subjected to the latter type of vibration. On the former type, about the most effective shock absorber is the one made out of a coil spring which supports the weight of the entire lighting fixture. Where lamps are installed without shock absorbers, their life can often be prolonged by letting them burn continuously, instead of turning them off when the light is not needed. This practice, however, is undesirable and expensive. I have found that in most cases where shock absorbers are installed on the lamps it is possible to turn them off when not needed without the shortening of the lamp life as was the case before installing them. These are two advantages in favor of shock absorbers on all lights.

After a lighting system has been gone over and put into good condition, it will require good supervision to maintain it in that condition or large lights will be put into sockets where they are not needed and vice versa. When a lighting system is given proper attention, it will not only show a greater return on the investment but will be of greater effectiveness.

Water Walls and Boiler Plant Economy

FACTORS TO BE CONSIDERED AND THEIR APPLICATION AS SHOWN BY PRACTICE AND EXPERIENCE

TWO PAPERS on the economy of using water walls for furnaces were presented at the National Fuels Conference of the A.S.M.E. in Philadelphia, one by Ollison Craig of the Riley Stoker Corp., the other by J. S. Bennett and P. N. Oberholtzer of the American Engineering Co. The former discussed the general conditions to be considered while the latter related more particularly to stoker-fired furnaces.

Efficiency Gain Small

Mr. Craig pointed out that, while each case must be considered on its own merits, in general water walls will increase efficiency but little by making it possible to use less excess air and carry higher CO_2. The chief use is to control furnace temperature thereby effecting saving in coal and in upkeep of furnace and stoker.

Water walls will increase capacity only about as much as the same surface added to the boiler since reduction of the temperature of gas entering the boiler passages will cut down the heat absorbed by the boiler. If boiler heating surface be reduced as water wall surface is added, this increasing capacity, exit temperature of the gases will be increased and heat recovery by economizer or air preheater must be provided or coal cost will be increased.

Slag from Molten Ash

In modern furnaces, forced operation results in high temperature which may cause undue expansion, may soften refractory walls so that they will fail under the weight of high walls, or may cause slag erosion from the molten ash flowing over the softened surface. These softened surfaces, in stoker-fired furnaces may also be damaged by rubbing of the moving fuel bed. Molten ash carried between the tubes may form slag and seriously decrease the area of gas passages; also it may cause bad clinker in the fuel bed, resulting in reduced combustion rate and possibly in burning of stoker parts.

Water walls, by absorbing radiant heat and reducing furnace temperature, tend to reduce these difficulties. As most of the troubles are due to molten slag or will be overcome if the temperature is lowered below that of ash fusion, limiting of furnace temperature to that at which ash softens will be sufficient to overcome these troubles.

After all, the one reason for using water walls is to decrease cost of steam production. This may be by

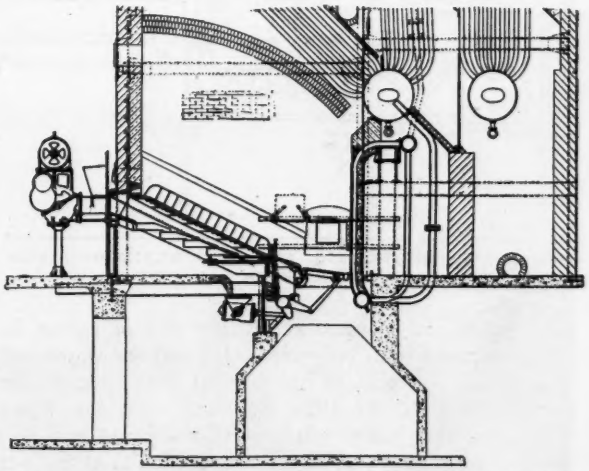


FIG. 1. WATER WALL AT REAR ONLY, EXTENDING INTO ASH PIT

increasing efficiency through reducing excess air and preheating it, by increasing capacity, or by using cheaper coal which has a lower ash fusion temperature. Whether money should be spent on water walls depends on whether these ends can be accomplished at a profit.

Water Walls Increase Capacity

If the output needed continuously is such that carrying high CO_2 results in slag troubles, it was shown by an example that it will pay to equip with water walls, so as to get higher efficiency by high CO_2. If, however, the high output is needed but a small part of the time, it will probably pay to run at lower CO_2 during the peak, use more excess air to keep down furnace temperature, and thus save the cost of the water walls.

Where increase of capacity is needed, water walls may be the answer as a square foot of water wall will

absorb several times as much heat as a square foot of boiler heating surface.

Stoker-Fired Furnaces

In the paper by Messrs. Bennett and Oberholtzer, several installations of water walls were described and compared, ranging from the St. Croix Paper Co.'s plant where the water wall cost was 28.3 per cent of the boiler

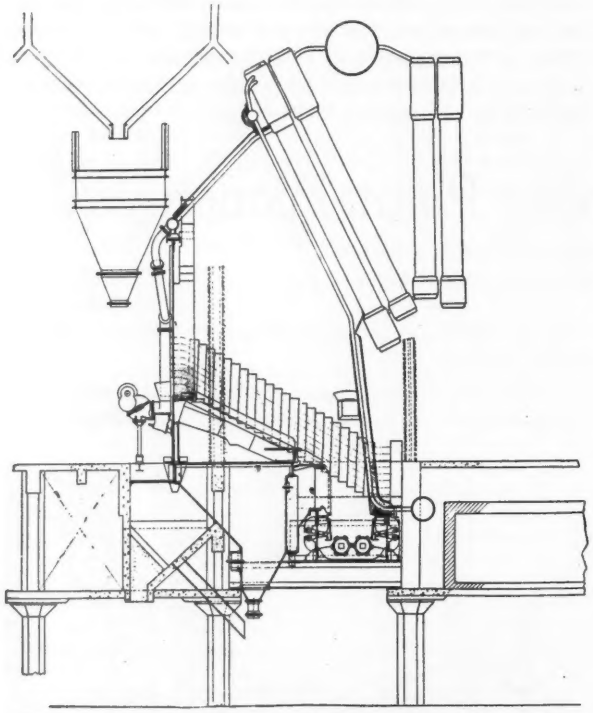


FIG. 2. WATER-COOLING ALLOWED EXTENDING FURNACE TO INCREASE CAPACITY

cost, boilers are operated at 310 per cent of rating, on good coal, rear walls only are cooled and the water-wall cost is 7.5 per cent of the annual coal cost, to the Lorain plant of the Ohio Public Service Co. where water wall cost was 60 per cent of boiler cost and 13.3 per cent of annual coal cost and operation is at 500 per cent of rating on poor coal, with front arch, rear and side walls water cooled.

If only one wall is cooled, it should be the rear carried down into the ash pit, because of elimination of trouble from ash at the end of the stoker. In the St. Croix plant, Fig. 1, such cooling resulted in a gain of one per cent in efficiency, increased stoker capacity and reduced maintenance.

Water-cooling of side walls up to the fuel line by tubes faced with metal plates is found good practice, the wall above the fuel line being cooled by air, by water tubes or in part by each. In any case, the cooling should be such that molten slag will not run down to form clinker in the fire bed.

As an example of design for severe conditions, the Westkraft station in Berlin, Fig. 3, operating at 410 lb. and 800 deg. F. with air at 500 deg. will give continuous output of 500,000 lb. of steam an hour for boiler rated horsepower of 2580, with coal of 11,000 to 14,000 B.t.u. As shown, all walls of the furnace are cooled, the tubes above the fuel line overhanging the lower block-faced section to form a drip ledge for slag.

By using water-cooled walls, it is possible to increase the furnace size to permit a stoker longer and wider than the boiler, walls being slanted outward as shown in Fig. 2. This has permitted increasing the capacity of existing plants by installing new furnaces without change in the boiler equipment.

Operating Experience

Discussion of the papers brought out facts from experience of plant designers and operators. In favor of the use of water walls were the increase in capacity and greater flexibility of steam generation, reduction of the outage time of boilers, control of furnace temperature and lower draft losses.

On the other hand, argument was advanced that the reduction in temperature is only near the walls, so that molten ash is still carried by gases in the center of the furnace; that limiting the wall temperature to that of ash fusion lowers efficiency; that waterwall surface costs some ten times as much per square foot as boiler heating surfaces and has less than ten times the heat absorption

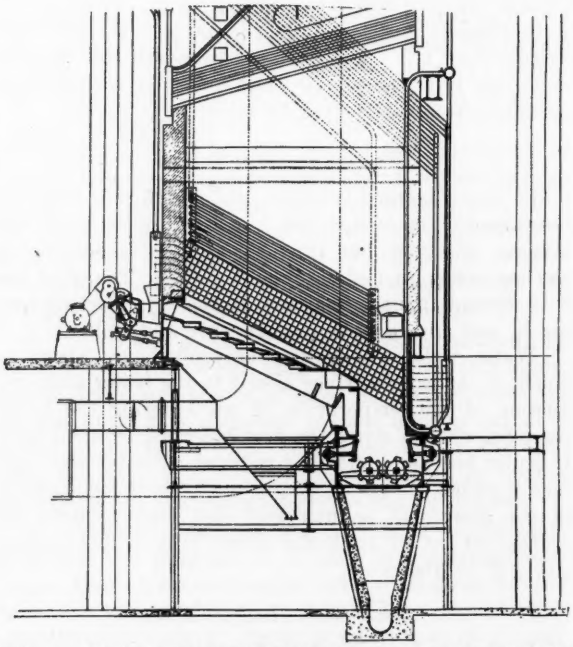


FIG. 3. BERLIN PLANT HAS WATER-COOLED SLAG LEDGE ABOVE FUEL LINE

rate; that there is added complication and cost for control and blow-off valves.

S. M. Finn pointed out that circulation in the boiler is primarily to make steam while in water walls it is to cool the tubes, hence no steam should be formed in the walls. This requires good circulation in wall tubes and European practice secures this by using small bare tubes with, if necessary, forced circulation, limiting heat absorption to 80,000 B.t.u. per sq. ft. per hr. For 300 lb. pressure, a wall 0.165 in. thick for 4-in. tubes is satisfactory but, if tube thickness is increased, heat absorption should be reduced below 85,000 B.t.u. per sq. ft. per hr. in proportion as the thickness is increased.

Thus for a thickness of 0.205 in. to carry 450 lb. the heat absorption intensity should be reduced to 70,000 B.t.u. per sq. ft. per hr. American practice uses larger water-wall tubes, covered with protecting plates, thus reducing heat absorption and avoiding incrustation from evaporation which would otherwise take place.

The covering needed on tubes is in proportion to heat liberation in the furnace and can be reduced if flame impingement on the walls is avoided. If, however, there is high intensity of heat liberation in the furnace and circulation is impeded, steam binding with consequent liability to burnt tubes will result. Design of water walls should, therefore, give simplicity, symmetry, provision for expansion, good adaptation to the boiler design and good contact of covering plates with the tube surfaces. Metal plates for rear walls and up to the fuel line in stokers seemed to be most common with refractory covering used on front walls and the upper part of side walls. For pulverized coal furnaces, operated at high percentages of rating, metal cover plates for all water walls seemed to be preferred, although several speakers favored refractory walls throughout and some stated that air-cooled refractory walls, sectionally supported are better than water-walls and cost little more than solid walls.

F. C. Daniels favored the use of small bare tubes with forced circulation, a velocity of 2000 to 3000 ft. per min. eliminating all steam film from the tubes and allowing absorption rate of 250,000 B.t.u. per hr. per square foot of projected tube area, thickness having little effect. He questioned the wisdom of putting in water walls and then covering them to reduce heat absorption.

For stokered furnaces, it was stated that the flame effect on the rear wall comes only as high as the front of the fuel bed, so that covering is not needed for the full height of the rear wall.

In general, such surface should be used as will give the furnace temperature desired but this temperature should be kept as high as possible without having slag difficulty. The gain to be expected is in better operating conditions and reduced operating costs rather than in efficiency. With present-day forcing of furnaces and boilers, the trend is to use water-walls and they seem to be giving satisfaction from both operating and economic standpoints.

Plant Operates Efficiently After 20 Years

TWO-STORY PLANT WITH TURBINES ON SECOND FLOOR BUILT IN 1908 STILL IN SERVICE AND SHOWING EXCELLENT PERFORMANCE. BY A. A. CRAWFORD*

IN 1907, THE CLEVELAND Construction Co., Cleveland, Ohio, erected a double deck power plant for the Youngstown & Ohio River Railroad Co., offices at Leetonia, Ohio.

This plant is located at West Point, Columbiana County, Ohio, and was placed in operation March, 1908. At that time, it was to furnish power for railway work only but later on furnished power and light for a number of towns and mines located along the railroad.

This plant presents a number of interesting features. Chief among these is the location of the turbo-generator units on the second instead of the first floor of the building, with the boilers directly underneath. This does away with the extensive steam pipe system necessary in most plants. The type of construction of the building reduces the vibration to a minimum and many advantages were gained from the arrangement. In round numbers, the main portion of the plant is 120 by 50 ft., while in the rear is a bay 20 by 55 ft. extending over a creek, which was deepened at this point to meet the needs of the plant. The building is of steel and brick construction. A complete self-sustaining steel frame was erected before the brick work was commenced. It, with the walls, rests upon a mass concrete foundation carried down to bed rock. It is a substantial looking building as well as one of pleasing appearance. The entire second floor of the main portion of the building is taken up by the turbine room, which is separated from the bay by the switchboard and columns.

Equipment consists of two Westinghouse 1000-kw., 400-v., 3-phase, 25-cycle turbine-generators, 1500 r.p.m., two 55-kw. exciters direct connected to two Westinghouse Standard engines, two 300-kw. rotary converters

FIG. 1. EXTERIOR VIEW OF 20 YEAR OLD PLANT

for supplying the railway load. Three 200-kw. motor generator sets for supplying power for mines near the plant. In the bay are located six 375-kw. oil insulated water cooled transformers, which step the voltage up from 400 to 22,000 v. Each turbine-generator is supported on four steel columns and connected at the top by 36-in. girders. The bed plate of the turbine-generators is set on the upper flanges of these girders with a 1-in. space between for leveling, which was filled with lead melted and poured in. The exciters, rotary converters and motor-generator sets were set on the finished concrete floor.

Steam generating equipment consists of five 400-hp. B. & W. Stirling boilers, 200 lb. pressure. Valves separate the different sections of the main header and the boilers are provided with automatic non-return valves.

*Superintendent of Motive Power, The Youngstown & Ohio River Railroad Co.

All header valves can be operated from the turbine room. For coal handling, a track was built on a trestle through the boiler room from a switch connecting the main track. A storage of about 800 t. coal is stored in front of the boilers and about 3000 t. stored on outside of building.

The stack is 175 ft. high and self sustaining, built on a concrete base; the breeching enters the base of the stack.

Because of the lack of experience at this time in this form of power station construction some apprehension was felt regarding the steadiness of the building and machinery. After 20 yr. operation, the walls of the

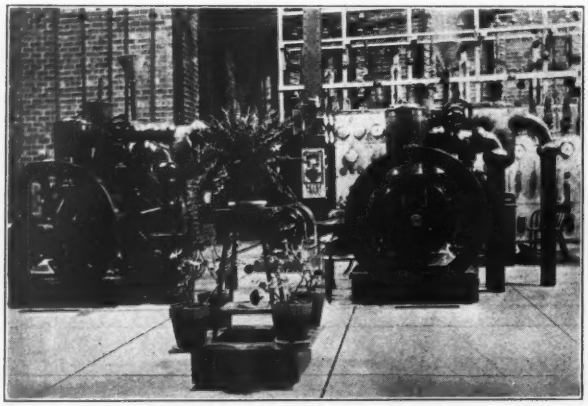


FIG. 2. TWO ENGINE DRIVEN EXCITER UNITS

building are firm and show no signs of cracking and are free from vibration.

I am giving an excellent illustration of how well this plant has operated. For a few years only one turbine was operated, the other being used as a stand by. Both were placed in service at the same time and their operating data are so nearly identical that the same figures apply to both units.

(a) Were first placed in service March, 1908.
(b) Outage due to regular inspection and repair, 0.1 per cent.
(c) Available for service, 99.9 per cent.
(d) Longest continuous run, 7 months.
(e) Average load carried by each, 1000 kw.
(f) Maximum load carried by each, 2500 kw.

As previously stated, they are used to carry a railway and mine load and each unit takes violent swing ranging from 0 to 2500 kw. In 1914 steam locomotives were replaced with electric locomotives for handling freight cars. After the electric locomotives were placed in service, it was necessary to run both turbines for several months at a time without a shutdown. Neither machine has ever given any serious trouble and both are still giving good service.

Operation of the two 300-kw. rotary converters is nearly identical to the turbines. They carry heavy overload from 75 to 100 per cent from 20 to 30 min. at a time.

The six step-up transformers are operated closed delta, two banks being provided, one bank for each turbine-generator. In the 20 yr. operation only one transformer failure has occurred. This was caused by lightning, the transformer being out of service about 12 hr. for repairs and filtering the oil.

Two to four boilers are operated at one time, depending on the load, the fifth being off for cleaning and repairs. After 20 yr. operation, we are still allowed 200 lb. steam pressure.

About 3 yr. ago, Crecelius and Phillips, consulting engineers, Cleveland, Ohio, conducted a test on the plant to determine what alterations or improvements should be made, or, if not operated efficiently to shut it down and buy power. The results may be summarized as follows:

The plant was operating with as high a degree of efficiency as could be expected with the present equipment. The steam consumption of the turbines was only slightly more than the guaranteed performance when new. The boilers were in good condition and free from scale. No alterations or improvements were recommended.

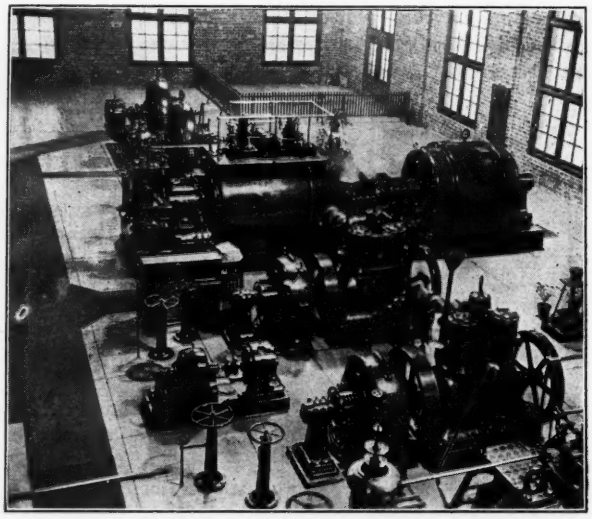
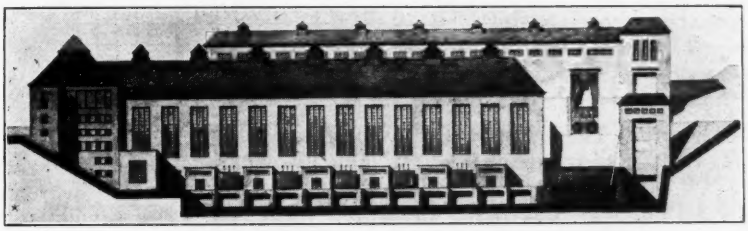


FIG. 3. A GENERAL VIEW OF THE TURBINE ROOM

They stated further that, in their opinion, the plant was in better condition and was operated more cheaply per kilowatt-hour than is ordinarily the case in plants of similar size and character. Originally, the plant was designed by W. E. Davis and C. W. Ricker, consulting engineers.

COMMERCIAL STOCKS of bituminous coal used largely for industrial purposes amounted to 37,500,000 t. on October 1, 1929, compared with 41,100,000 t. on October 1, 1928, and with 33,100,000 t. on July 1, of this year, according to the quarterly survey just completed by the United States Bureau of Mines, Department of Commerce. Exports during the third quarter of 1929 averaged 410,000 t. a week against 342,000 t. in the previous quarter and 399,000 t. during the same period of last year. The weekly rate of home consumption during the third quarter amounted to 8,713,000 t. a week compared with 8,651,000 t. in the previous quarter. Compared with the corresponding quarter of last year, the current rate of home consumption shows an increase of 5.7 per cent, reflecting somewhat improved business conditions.



Where the River Shannon Flows

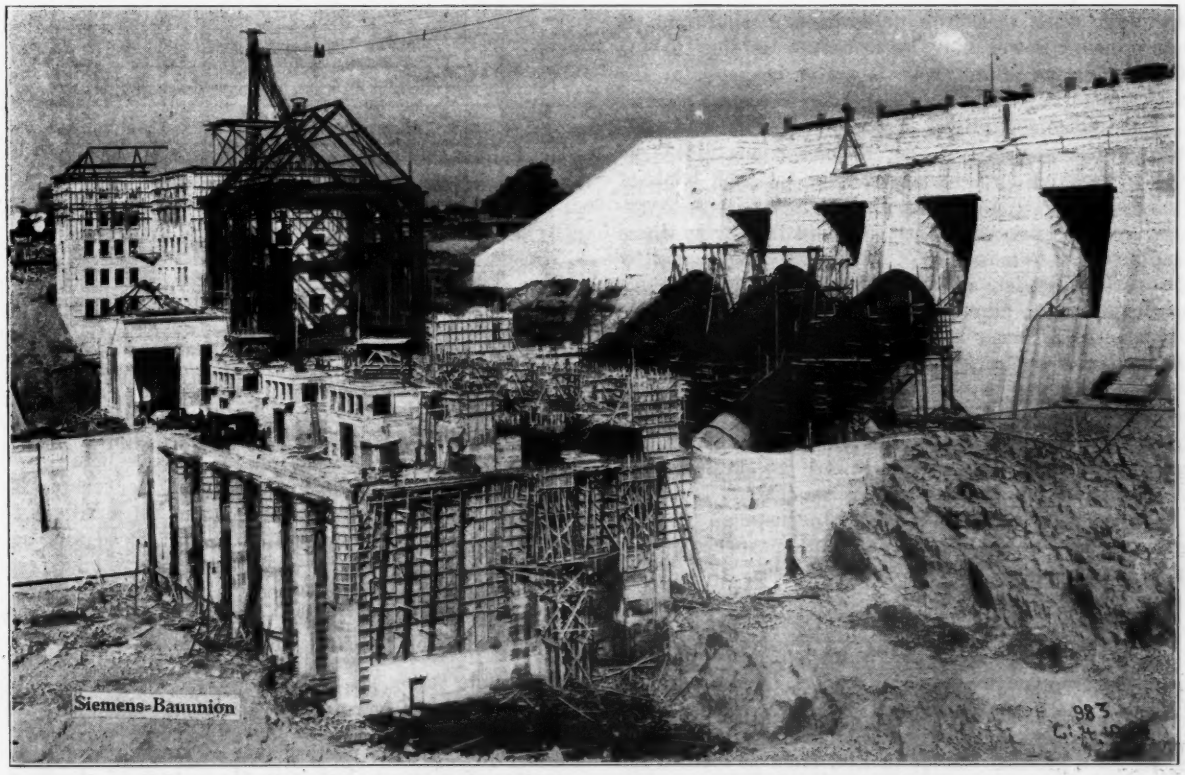
AT ARDNACRUSHA, on the River Shannon in Ireland, the Irish Free State has built a 180,000-kv-a. hydroelectric plant to supply power for an electrification scheme designed to transmit power to the entire country for traction, manufacturing and domestic service. The initial capacity of the plant is 90,000 kv-a, in three units, the design providing for a total of six machines. The entire engineering and construction work was carried out by Siemens-Bauünion and Siemens-Schuckert Works, using both Irish and German labor.

Ardnacrusha, the site of the plant, is about three miles north of Limerick. At Parteen Villa, a weir for controlling forebay water level has been built, provided with 6 sluices each equipped with a roller gate. Storage capacity at present is about 11,500,000,000 cu. ft.; the ultimate capacity will be about 30,000,000,000 cu. ft.

The intake building running across the head race above the power house is essentially a huge concrete gravity dam with wing walls.

Water level fluctuates about 21 ft. on account of the tide below the power plant, thus causing the available head to vary. Under these conditions, three Francis water turbines have been installed as the initial installation. These units, made by J. M. Voith and Escher Wyss & Co., each have a capacity of 31,000 hp. at 92 ft. head and of 38,600 hp. at 110 ft. head, operating at 150 r.p.m. These turbines drive three S.S.W. alternating-current generators, each designed for 30,000 kv-a., 10,500 v., 150 r.p.m. Voltage may be varied 5 per cent and can be raised to 11,000 v. at full load. Guaranteed efficiency is 95.5 per cent at full load and 94.2 per cent at half load without bearing friction.

Distribution system of the Irish Free State comprises 116 mi. of six-conductor 110-kv. line from Ardnacrusha to Dublin and three-conductor 110-kv. to Cork, besides 1040 mi. of 38-kv. system in four loops. At present 60 of the 30/10-kv. substations are required for the local distributing systems, from which power is supplied to consumers at 380 and 220 v.



GENERAL VIEW OF SHANNON HYDROELECTRIC PLANT, DESIGNED FOR 180,000 KV-A. ULTIMATE CAPACITY, SHOWING DAM, PENSTOCKS FOR FIRST THREE UNITS OF 30,000-KV-A. EACH, AND POWER HOUSE SUPERSTRUCTURE AND SUBSTRUCTURE

Shop Testing of Steam Turbines

BECAUSE OF THE MANY FACTORS THAT ENTER INTO THE PERFORMANCE OF STEAM TURBINES, MANY TESTS ARE NECESSARY. BY F. B. BROWNELL*

TURBINE TESTS in general may be divided into the two classifications, commercial and experimental. The first group consisting of power, valve setting, speed regulation, overspeed trip and running tests are made on practically all turbines in order to place the machine in good condition before shipment.

In the power test, the horsepower delivered at the turbine shaft, or kilowatts delivered at the generator

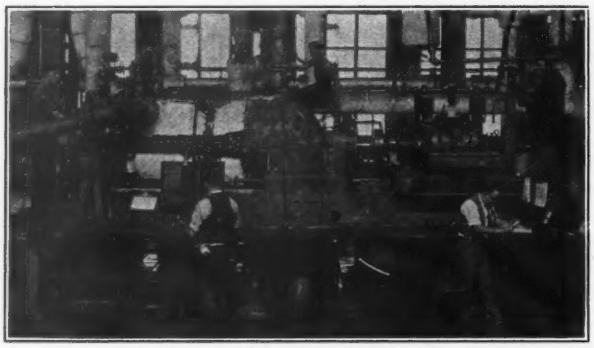


FIG. 1. A 1000-KW. CONDENSING TURBINE UNDER TEST

terminals, when operating under design conditions, is determined. Power may be measured at the turbine shaft by means of an accurate water brake or at the generator terminals by means of water rheostats.

Simultaneous readings of speed, brake load and first-stage nozzle pressure are taken for various first-stage nozzle pressures up to the maximum for each bank of first-stage nozzles or arrangement of inlet valve openings. Power pressure curves are plotted from these readings as shown in Fig. 2. The power developed by the turbine under each condition at full first-stage nozzle pressure (allowing for a definite pressure drop through the governor valves for regulating purposes) is then taken from each curve, for comparison with the shaft horsepower values for which the turbine is designed. This method of testing gives results derived from a number of test points, rather than from one point only, therefore it tends toward greater accuracy of deductions by ironing out inconsistencies.

Valve setting constitutes an adjustment of the governor and valve linkage to secure proper sequence of valve openings under governor control.

SPEED REGULATION TEST

The speed regulation test is to determine the drop in speed from no load to full load as a percentage of full-load speed as determined by the governor charteristics and by the linkage adjustment. If readings of speed for a gradual change in load from no load to full load were taken and the corresponding drop in speed was found to be 100 r.p.m., the speed regulation is then—

$$\frac{3700 - 3600}{3600} \times 100 = 2.8 \text{ per cent}$$

For the overspeed governor test the objective is to adjust the speed at which the overspeed trip operates, in order to close the automatic trip and throttle valve and shut down the turbine in case of emergency. The turbine may be overspeeded by compressing the governor spring. The overspeed trip is then adjusted to operate and close the trip and throttle valve at a speed approximately 10 per cent higher than the maximum operating speed. This test is repeated several times

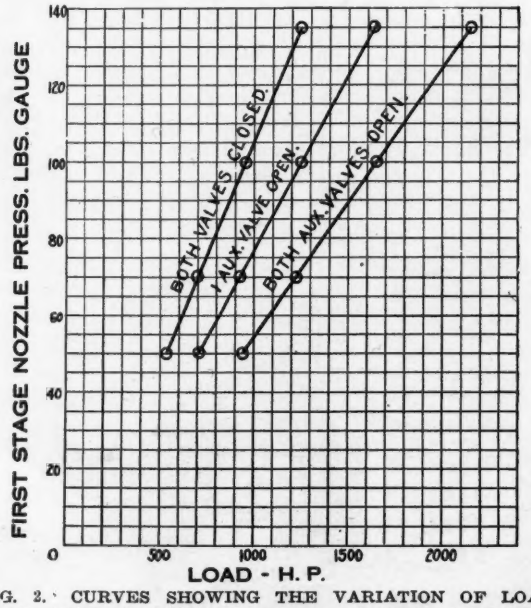


FIG. 2. CURVES SHOWING THE VARIATION OF LOAD WITH NOZZLE PRESSURE; 150 LB. GAGE SATURATED STEAM, 28 IN. VACUUM

after the adjustment is complete, to insure that the trip operates at the same speed at each successive trial.

After the other tests are completed the turbine is assembled with the driven machine and all auxiliaries. The entire unit is then operated at full speed and no load to observe the general operation with special reference to general appearance, freedom from vibration and functioning of the lubricating system and all points not observable during the previous test runs.

EXPERIMENTAL TESTS

Experimental testing does not mean laboratory testing to determine the performance of steam turbines as a matter of research, but is in the nature of checking this performance as calculated on a scientific basis from thoroughly understood principles. These tests are fre-

*Turbine Engineering Department, Elliott Co., Jeannette, Pa. From an article in Powerfax.

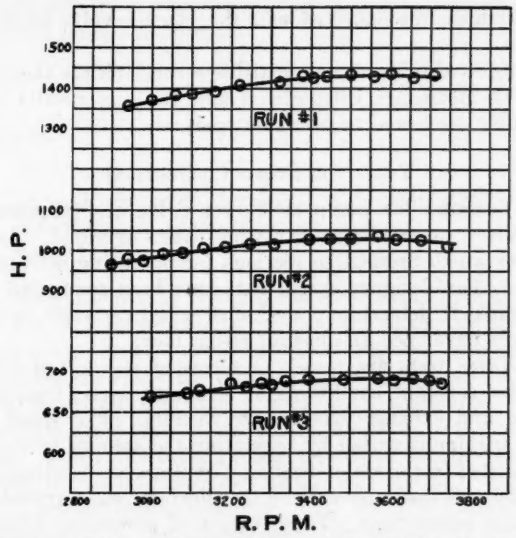


FIG. 3. THE POWER OUTPUT FOR CONSTANT STEAM FLOW VARIES SLIGHTLY WITH THE SPEED. CONSTANT FLOW FOR EACH RUN

quently witnessed by the purchaser when such a test is definitely specified in the contract, but are commonly initiated and conducted by the turbine engineering department as a running guide to theoretical practice.

Some experimental tests that have been conducted are described.

Water rate tests may be run to show that the steam consumption of the turbine actually meets the specified figures for rated steam conditions over the range of load specified. This is the test most frequently run as a witness test, but it is also frequently conducted as a check on design methods. The essential data required to determine the steam consumption of a turbine consists of the following three items which are determined as described:

a. Horsepower at the turbine shaft or kilowatts at the generator terminals. For experimental testing, it is preferable to measure the output of the turbine at the turbine shaft since this is the most direct method. One way of testing which has been found advantageous, in order to obtain accurate values for power developed at any given nozzle pressure and speed, is to vary the turbine speed and take a large number of simultaneous readings of speed and brake load at constant nozzle pressure. These readings are taken over a speed range of approximately 20 per cent. Power-speed curves as in Fig. 3 are then drawn through these points and the power developed by the turbine at the desired speed is taken from these curves. This gives test values for the desired speed as a result of a field of test points instead of from one point only.

b. Net flow through the turbine, which is equal to the total water pumped out of the condenser by the circulating pump minus the amount of condenser leakage for the same period of time. The amount of steam per hour is determined by weighing the water pumped from the condenser in two tanks mounted on platform scales. Condenser leakage (which is the leakage of circulating water through the tubes into the condensate) is taken for one hour runs immediately before and after each test. The condenser used in connection with these tests is an Elliott surface condenser, used for test purposes only, and is kept in very good condition. For this reason, condenser leakage forms a small correction on the observed condensate readings.

c. Steam pressure, temperature and vacuum are read at stated intervals. Steam pressure is read on an accurate gage above the turbine throttle and maintained by manual operation of the inlet valve from the steam main. (Fig. 1.) Steam ring pressure is held at a predetermined value by means of a dead weight gage and hand throttling. Temperature of the steam is read on an accurate thermometer inserted in the steam line above the turbine throttle. Vacuum is read on an accurate mercury column connected to the turbine exhaust and maintained at a constant value by admitting air to the turbine exhaust if necessary. Readings for vacuum are referred to barometer readings taken during the test. All gages are carefully calibrated before and after each test and calibration readings of the hand tachometer are taken by means of a variable speed dynamometer. Some results obtained on recent water rate tests are illustrated in Fig. 4.

For superheat correction tests, controlled temperatures as high as 700 deg. F. are available with separately fired superheaters. It is therefore possible to test turbines at the desired degree of superheat, eliminating the necessity of correcting results for wide variation in superheat.

To investigate the effect of superheat on turbine performance, water rate tests are conducted, all conditions remaining constant for respective tests runs with the exception of the steam temperature. The temperature of the steam is varied by 50 or 100 deg. F. and the readings obtained are compared for the correction due to variation in superheat. Figure 5 shows results of one test of this nature.

Tests of Segregated Elements

Steam turbines may be considered as being composed of two sections, the high-pressure element and the low-pressure element. The high-pressure element is usually built with relatively small pitch diameters, small nozzle areas and short bucket heights to suit the low specific volume of the steam at high pressures. Frequently partial admission is used in the diaphragms and the high-pressure element may consist of a combination of

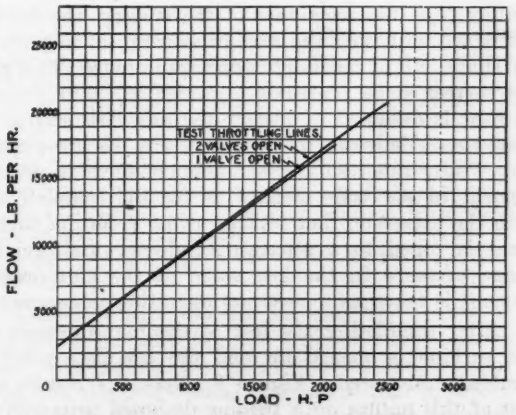


FIG. 4. RESULTS OF A WATER RATE TEST ON A 3600-R.P.M. TURBINE WITH 300 LB. GAGE, 213 DEG. F. SUPERHEAT STEAM, 27½ IN. VACUUM

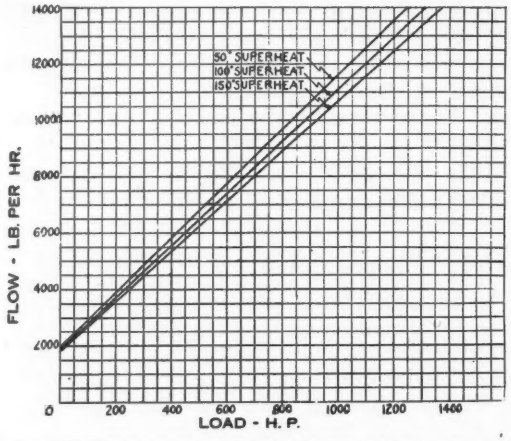


FIG. 5. SUPERHEAT MATERIALLY INCREASES THE TURBINE EFFICIENCY. TEST MADE ON A 3600-R.P.M. TURBINE USING 150 LB. GAGE STEAM AND A VACUUM OF 28 IN.

pressure and velocity staging. Diameters of the wheels in the low-pressure end are considerably larger to suit the larger heat drops available per stage. Large nozzle areas and corresponding long buckets are used due to the greatly increased specific volume of the steam.

Nozzle and bucket angles are different in the two elements and the steam parts may be of entirely different type, all of which increases the complication of theory required to determine the performance on a calculation basis.

It is advisable at times to test the two elements separately, as a check on the theoretical design of these two widely differing portions of a common unit. These tests are of especial value in cases of extraction and mixed-pressure turbines since it is difficult to conduct tests on these units under design conditions.

When it is desired to test the various elements of a turbine separately, it is customary to test the high-pressure element alone and then test the complete turbine. From these tests, the performance of the low-pressure element is readily determined. Due to the difficulties involved in providing an adequate supply of low-pressure steam at correct moisture or superheat content, it is not considered advisable to attempt the testing of low-pressure elements by themselves and the foregoing method gives reliable results suitable for the purpose.

To test the high-pressure element of a turbine separately from the remainder of the staging, the rotor is assembled with only the high-pressure discs in place on the shaft. All of the diaphragms are in place. This gives the correct stage pressures at which the high-pressure element is designed to operate for any flow and at the same time eliminates rotation losses in the low-pressure end. Water rate tests are then taken of the high-pressure element in the same manner as for the complete unit with the exception that leakage steam from the packing cases is piped to a separate condenser and weighed. Stage pressure in the last stage of the high-pressure element is taken as a check on operating pressures.

After completing the test of the high-pressure end the turbine is opened up and the complete rotor assembled and tested. Figure 6 shows the results of a test of this nature on a turbine designed primarily for extraction of steam for process work. During the test of this unit, the bleeder outlet was closed, the bleeder mechanism disconnected and the bleeder valve blocked open.

Tests of this nature constitute a check on the theoretical performance calculations and the test results are readily converted to a usable basis.

Tests for Speed Correction

Turbines for pump or blower drive are frequently required to operate over a wide range of speed. As a check on theoretical corrections for operating at speeds other than designed speed, tests have been conducted on turbines to determine the effect of speed variation on the power developed at constant steam flow.

These tests are merely a series of power test runs under constant conditions of steam pressure, temperature and exhaust pressure or vacuum. The speed of the turbine is varied by regulating the amount of water admitted to the water brake. Simultaneous readings of speed and load delivered to the platform scale are taken as for power tests. These values of power are plotted

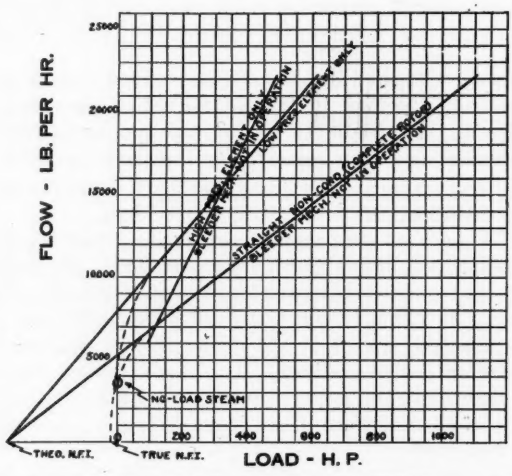


FIG. 6. STEAM FLOW CURVES THROUGH A TWO-ELEMENT BLEEDER TURBINE. STEAM PRESSURE 225 LB. GAGE, SUPERHEAT 100 DEG. F., BLEEDER PRESSURE 50 LB. GAGE, EXHAUST PRESSURE 5 LB. GAGE

against speed and a curve drawn through the points. Figure 7 shows a speed correction curve that has been evolved from a number of tests. This is an average curve and may be applied approximately for either condensing or noncondensing designs.

For turbines that are required to start under any considerable load or which are subject to sudden stoppage due to blocking of the driven machine, it is desirable to know the relation between the full-load torque and the standing torque. Tests for standing torque have been recently conducted for this purpose.

Standing torque is measured by blocking the turbine rotor to prevent rotation and measuring the load delivered to an accurate platform scale by a beam of known length bolted to the coupling. The torque is then calculated from the formula

$$T = WL, \qquad (1)$$

where:

T = Torque in foot pounds.
W = Net weight delivered to the scale in pounds.
L = Length of arm in feet.

Torque at normal operating speeds is readily calculated from the formula

$$T = \frac{33{,}000 \times Hp.}{2\pi N} \qquad (2)$$

where:

T = Torque in foot pounds.
hp. = Horsepower developed at turbine shaft.
N = Speed in revolutions per minute.
$\pi = 3.1416$

By applying the power-speed correction curve shown in Fig. 7, it is possible to estimate the torque developed over a considerable range in speed. Figure 7 also shows a correction curve for torque plotted against speed. It will be noted that the torque line (calculated from variable speed tests at constant steam flow) is a straight line. The value for standing torque, or torque at zero speed is also taken directly from test results.

Tests are sometimes conducted for the purpose of establishing a theoretical basis for estimating certain conditions of operating performance which are not readily calculated. Figure 6 illustrates the following three points in addition to the test of segregated elements.

a. Theoretical no-flow intercept is a purely imaginary point and is the negative power at which a straight throttling line of power plotted against flow would intercept the line of zero flow. The no-flow intercept is always negative and may be said to depend entirely on the last few stages in the turbine and the exhaust pressure. In Fig. 6 it will be noted that the low-pressure line is drawn to the same N.F.I. as used for the entire machine, although this gives total high-pressure powers plus low-pressure powers not quite in accordance with Tests of Segregated Elements.

b. True no-flow intercept is the horsepower loss of the turbine at full speed and zero flow. This loss is obtained by measuring the input to an electric motor, of known efficiency, driving the turbine at full speed with designed exhaust pressure or vacuum in the casing.

c. No-load flow is the flow required to just overcome the rotation losses of the turbine and develop full operating speed without delivering power to the turbine shaft coupling. The test is taken by operating the turbine, without water brake or any driven machine, under design conditions.

These points are illustrated in Fig. 6 and the approximate shape of the low-pressure and straight noncondensing lines are indicated as broken lines, derived from these points.

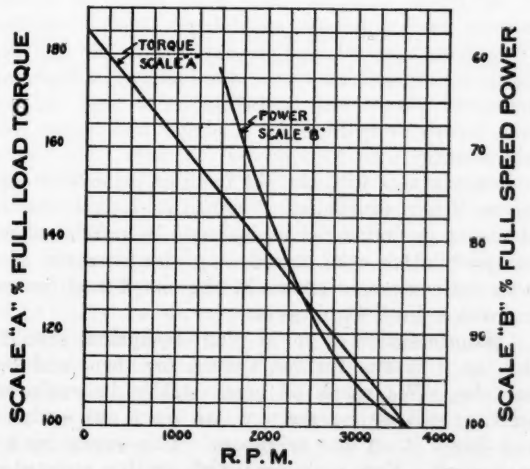


FIG. 7. POWER AND TORQUE CORRECTION CURVES FOR VARIABLE SPEED TURBINES

A. S. H. & V. E. to Hold 36th Annual Meeting

PROGRAM has been announced for the Society's 36th annual meeting to be held in the Benjamin Franklin Hotel, Philadelphia, Jan. 28-31, 1930. Local chapter members, under the leadership of John Cassell, honorary chairman, and R. C. Bolsinger, general chairman, are coöperating. Committee chairmen are: Lee Nusbaum, finance committee; M. C. Gillett, ladies' entertainment; F. D. Mensing, transportation and publicity, and A. J. Nesbitt, banquet.

The first official function will be the meeting of the council Monday, Jan. 27. During the day a series of conferences of technical committees will be held. The first general meeting will be opened by President Lewis at 9:30 a. m. Tuesday, Jan. 28, and on succeeding days morning sessions will be held in the Benjamin Hotel and afternoon sessions beginning at 2:30 p. m. will be held at the Commercial Museum where the First International Heating and Ventilating Exposition is to be open during the entire week of Jan. 27 to Feb. 1.

The program committee, composed of H. H. Angus, chairman; A. J. Nesbitt and Prof. F. B. Rowley, announces a tentative list of subjects which are proposed for discussion at the technical sessions:

Preventing Condensation on Interior Building Surfaces, by Paul D. Close.

Pressure Difference Across Windows in Relation to Wind Velocity, by J. E. Emswiler and W. C. Randall.

Some Studies of Aeration of Garages, by W. C. Randall and L. W. Leonhard.

Electric Power Generation by Process Steam, by L. A. Harding.

Air Infiltration Through Various Types of Brick Wall Construction, by G. L. Larson, D. W. Nelson and C. Braatz.

Air Conditioning of the United States Capitol, by L. L. Lewis and A. E. Stacey.

Stokers for Domestic Heating, by R. V. Frost.

A Review of the Developments in Domestic Stoker Design, by Joseph Harrington.

Welding of Pipe for Heating Systems, by F. W. Johnson.

Automatic Controlling Devices for Heating Systems, by F. I. Raymond.

Electric Heating for Homes, Factories and Other Buildings, by W. S. Scott.

Measurement of the Flow of Air Through Registers and Grilles, by Davis.

Surface Transmission Coefficients, by F. B. Rowley.

Measurement of the Absorption of Heat from the Sun's Rays, A.S.H.V.E. Laboratory.

Wind Velocity Gradients near a Wall, A.S.H.V.E. Laboratory.

Time has been allotted not only for a visit to the Exposition but also for side trips and tours of inspection. Bus service has been arranged for between the hotel and the Commercial Museum so that members can go to sessions or to see the exposition at convenient times.

Overfire Air Injection

BEING INTERESTED in overfire air and furnace design and having specialized in this particular part of the power plant for about 8 yr., I was interested in the article on Furnace Too Small and Too Low Causes Slag and Smoke, which appeared on page 1136 of the Oct. 15 issue.

In my experience, air introduced through tuyeres in the front wall has little velocity and tends to blanket the front wall instead of mixing with the gases at any appreciable distance from the wall. Side wall tuyeres serve only to minimize clinker along the side walls.

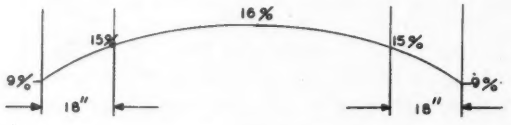


DIAGRAM SHOWING RELATIVE PERCENTAGES OF CO_2 FOUND AT DIFFERENT POINTS ALONG A CROSS SECTION OF THE FURNACE, TAKEN ABOUT 12 IN. FROM THE FRONT

There is an excess of air along the side walls even with low side tuyeres, only about 9 per cent of CO_2 being at the side walls near the front when there is an average of 13.5 per cent of CO_2 in the center of the third pass. At a section about 12 in. from the front wall, the relative amounts of CO_2 would be as illustrated in the sketch.

In order to introduce secondary air over the fire in such a manner as to be effective, with underfeed stokers and without Dutch oven construction, it is necessary to use refractory nozzles located above the fuel bed and having the jet of air directed about 30 to 45 deg. below the horizontal, aimed at the coking zone. Cast-iron nozzles could be used but that portion of the nozzle exposed to the radiant heat would burn out. The nozzles should be designed to distribute the air evenly across the furnace. Also they should have a 6-deg. divergence of their sides from outlet to inlet so as to convert the maximum amount of available static pressure into velocity head in order to secure maximum penetration and turbulence. The air for the nozzles should be supplied in parallel with the underfire air so that the secondary air will vary directly with the primary air.

Belleville, N. J. H. H. BAUMGARTNER.

Industrial Power Plants Versus Central Station Equipment

Several months ago, a most amusing situation presented itself to the writer when in the market for power plant material and equipment. A salesman, in presenting an argument on the merits of his merchandise, as to the performance in this particular plant, showed that practically all of the large central stations all over the country were using his equipment. True and admittedly his arguments were able and his equipment, as to quality and performance was first class, but, it just didn't fit in this industrial plant.

The picture is this: as soon as consulting and operating engineers get over the idea of being copyists of central station plant equipment, to be applied to the average industrial plant, they will be on the way to become successful in solving industrial plant problems.

By careful scientific research, the advantages of higher pressures have been obtained but obtaining them has caused many manufacturers either to go bankrupt or consolidate their finances with other manufacturers of steam appliances, to survive the experimental stage, in plants where standard material would not stand up.

Central stations have been largely responsible for mergers of this kind. We have yet to hear of industrial manufacturers of commodities, the backbone of our country, who have developed such high grade steam efficiency in their plants, that engineering departments of equipment manufacturers must merge or refinance to solve hard problems pertaining to steam equipment.

Offering central station equipment for industrial plants means nothing to the development of high grade industrial plants but operating on a true industrial basis means everything for a bigger and better industrial country.

Many plants with the old familiar boiler and engine rooms, if new equipment, designed exclusively for such plants on an industrial basis, could be purchased without prohibitive cost, would stop the purchase of old worn out equipment known by that much used favorable expression Used Equipment.

Manufacturers of power plant equipment should see this, as it means further success for them and every one else. We speak of great strides in engineering activity, still we replace our own worn out equipment, and dump it on our neighbors. This surely isn't advancement. New equipment with written guarantee to the purchaser on a net earning power over a period

of years, is what we need more than citation of what the other fellow does.

Transfer of heat from the boiler to the switchboard at the lowest possible cost is as good an investment on new equipment as a 6½ per cent bond would be on the best real estate to be had in the country.

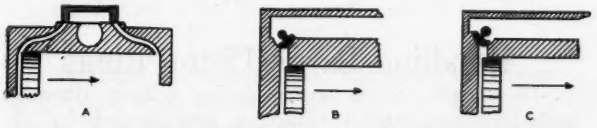
If the central station can't benefit the little fellow by its researches, then let the manufacturer assist him by specializing on power plant equipment that will benefit him, and help him to produce. Just give the little fellow an opportunity, that's all he wants.

Milwaukee, Wis. L. A. CORWIN.

Even though some of the equipment developed for central stations, is not directly available for industrial plant use, the principles and methods are often capable of adaptation and equipment of modification so as to be applied with benefit to the economy of small industrial plants as well as large ones. Keeping and study of records to determine what a plant is really doing and where its greatest losses occur is a first step toward better economy. After getting the best possible out of present equipment, the way is open to study the advanced practice and improved equipment of central stations and the best industrial plants to determine what new equipment will show a good return on investment. Twelve hundred pounds pressure will not be the answer for small plants but 400 lb. may be. Whatever the answer, equipment has been developed to meet the demands of the central stations which have pioneered in development and almost certainly manufacturers will be glad to consider such modification as may be necessary to need industrial plant requirements when they know what these are and that there is a demand for such modified equipment. Editors.

Positive or Direct Valve-Gear Action?

"ARE CORLISS VALVES of the direct or indirect type?" seems to have been answered rather poorly on page 1137 of October 15 issue. My understanding of the terms



A AND B ARE EXAMPLES OF DIRECT VALVE ACTION WHEREIN VALVES AND PISTONS TRAVEL IN THE SAME DIRECTION, WHILE C REPRESENTS INDIRECT ACTION, WHERE THE VALVE AND PISTON MOVE IN OPPOSITE DIRECTIONS

"direct" and "indirect" is that they refer to the travel of the valve in relation to the travel of the piston with the piston at the end of the stroke. If the valve travels in the same direction as the piston, it is direct but, if it travels in the opposite direction, it is indirect action. It makes no difference whether the valve is plain slide valve or rotary, as can be seen from the illustrations.

In A, the eccentric is ahead of the crank and there is no rocker to reverse the direction so it will pull the valve open toward the crank end or in the same direction as the piston will move. This is direct action. In B, the same thing will happen but in C the valve will open in a direction opposite to the piston's movement, hence is indirect in action.

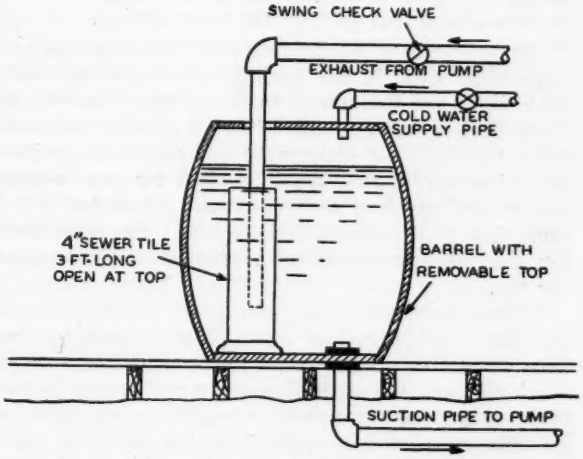
This shows that Corliss valves may be either direct or indirect. The position of the eccentric has nothing to do with it as it is entirely governed by the way the bell cranks are hung. On most single eccentric Corliss engines, the exhaust valve motion has been reversed by the action of the wristplate as connections are taken off below the center and are, therefore, usually indirect.

A quick way to identify the type of Corliss valves is to consider the dashpot rod arms. If they are between the valve stems, the valves are direct but if they are outside the valve stems, the valves are indirect in action. This must be so in order for the dashpots to close the valves in the opposite direction from that in which they open.

Turners Falls, Mass. WILLIAM W. WHITE.

Emergency Feedwater Heater

VISITING A SMALL power plant in the back country, where the boiler feed apparatus consisted of a duplex steam pump, I saw an application of ingenuity on the


SWING CHECK VALVE
EXHAUST FROM PUMP
COLD WATER SUPPLY PIPE
4" SEWER TILE 3 FT. LONG OPEN AT TOP
BARREL WITH REMOVABLE TOP
SUCTION PIPE TO PUMP

FEEDWATER HEATER OF THE SIMPLEST TYPE

part of the engineer that was both admirable and effective in reducing a waste for his employer.

During former summers, the engineer told me, the pump exhaust had been wasted as there was no feedwater heater and no prospects of getting one. Securing his employer's permission, the engineer rigged up the device shown in the sketch, which supplied him with a certain amount of warm boiler feedwater where formerly he had to use cold spring water. The swinging check valve was installed to prevent water from backing up through the exhaust pipe when the pump is shut down and the steam condenses in the pipe. The valve in the cold water supply line regulates the flow so that the water level in the barrel is kept a few inches above the top of the sewer tile.

Crackling noise is heard for a short time in the sewer tile when the pump is started. As soon as the water in this pipe has been warmed, most of this noise stops. As the heated water flows out slowly, cold water enters. A homemade separator which removes quite a lot of the oil from the exhaust was installed in the exhaust steam line.

Most, if not all, of the crackling noise would be avoided if the tile pipe were raised about ½ in. above

the bottom of the barrel so as to allow the water to flow in the same direction as the entering steam. Although it may not seem proper to use a wooden barrel as shown, the engineer declared the one used, which is of heavy construction bound with strong iron bands, had been in use for nearly a year without leaking.

Toronto, Canada. JAMES E. NOBLE.

Simultaneous Flue Gas Sampling

DURING PRELIMINARY examinations and studies for the increase of efficiency in an isolated steam plant, it became desirable to collect and send away for analysis, a considerable number of samples of flue gas which were to be taken under various conditions of operation.

It was considered desirable to take samples of gas from four places inside of the boiler setting and three samples were to be drawn from each place, one sample just after the boiler furnace had been stoked, another soon after the hydrogen content of the fuel had been burned out and the last to be taken just before replenishing the fire. Thus, 12 samples of flue gas were to be drawn from four parts of the boiler setting.

Some lengths of ⅜-in. black pipe were procured and holes were made in the setting so that the pipe ends could be thrust through to the exact point from which it was desired that a sample of gas be drawn. Although fitted together, the pipes were not placed in position until just before they were required for use, because unprotected pipes of such small size would last but a short time, if exposed to furnace heat. The holes made for the pipes were carefully plugged until required for use.

Fifteen 1-gal. glass jugs were procured, well cleaned and fitted with paraffined corks of proper size to close them effectively. Twelve of these jugs were to be filled with gas, the other three were for reserve in case of breakage and for priming the pipes. An ounce of paraffin was placed in each of the jugs and they were then filled with water and packed in a barrel of water which was kept hot enough to melt the paraffin. Thus, all the bottles were kept corked and full of warm water and melted paraffin.

A wooden stand, about chest high, was made to support a bottle upside down and to allow free access to the cork. An extra cork was pierced with two holes through which pieces of small metal tubing were passed and cemented so as to make them water and air-tight. One piece of the tubing was made long enough to reach to the bottom of the bottle and project 2 in. outside of the cork. The other piece was made flush with the inside of the cork and to project fully 6 in. outside of the cork. Two pieces of rubber tubing were attached to the projecting metal tubes and a pinch-cock was placed upon each piece of tubing.

When ready to take a gas sample, a bottle filled with warm water and melted paraffin was removed from the "hot-barrel," its cork removed and replaced with the two-tube cork. The bottle was placed upside down upon the stand and the free end of the rubber tube immersed in a dish of water. With this arrangement, should water begin to flow from the rubber tube, gas would be drawn from the furnace through the pipe. Should no water flow from the tube, the flow could be started by sucking the tube slightly with the lips.

As soon as the air and dead gas was removed from the pipe, the pinch-cock or clothes pin was applied and the partly emptied bottle removed from the stand and replaced by a full bottle which had been prepared as before. This bottle was then filled with gas direct from the boiler setting. This procedure avoided any contamination with any air which might chance to be in the long pipe. The layer of paraffin floating on the water in the jug, effectually prevented absorption of any portion of flue-gas which might otherwise come in contact with the displaced water.

Should it be considered necessary to take the four samples of gas simultaneously, it would be necessary only to rig up four cork tubes and supply one more paraffined bottle. It is unnecessary to use paraffined bottles for clearing out the pipes; plain water in the bottles may be used for the preliminary removal of the air in the pipes.

Indianapolis, Ind. JAMES F. HOBART.

Lubrication Under High Temperature Conditions

NOT LONG AGO, a large concern in the middle west had been experiencing difficulties in moving its oven trucks after they had been in the ovens. Due to the intense heat of the ovens the wheels of the trucks would stick and it was difficult to roll them out.

To eliminate this difficulty, 500 of these trucks were equipped with special fittings which it was thought would solve the problem. But no change was made in the lubricant which was unsuitable for their purpose. No improvement was noted. The high temperature in the ovens still caused the oil to carbonize and it was almost impossible to turn the wheels. Several other greases were tried but the results were always the same.

Employment of a high grade enameling conveyor oil which could be applied by means of an ordinary squirt can solved the problem and there is no more carbonizing or sticking of wheels.

Newark, N. J. W. F. SCHAPHORST.

Handling Large Piston Rings

IN SETTING up an engine having a 24-in. diameter cylinder, considerable difficulty was caused by the springing of the heavy piston rings which prevented the piston from entering. The trouble was overcome by using a circular band of flat iron ⅛ in. thick and about 1 in. wide, with right angle pieces welded to its ends and drilled for a ¾-in. bolt. By means of this device, the rings are drawn down tightly to the surface of the piston, permitting it to be driven up. The band is then loosened for the second ring and the process repeated for each additional ring.

Los Angeles, Calif. W. D. CAMPBELL.

ALL GLUES have more or less odor, which most people dislike. To prevent this smell in such a manner as not to impair the strength or tenacity of the glue, add a teaspoonful of saltpeter to the ordinary glue pot. This will not only kill the odor but will make the glue dry faster and become harder.

VERTICAL tandem compound engines are known as steeple compound.

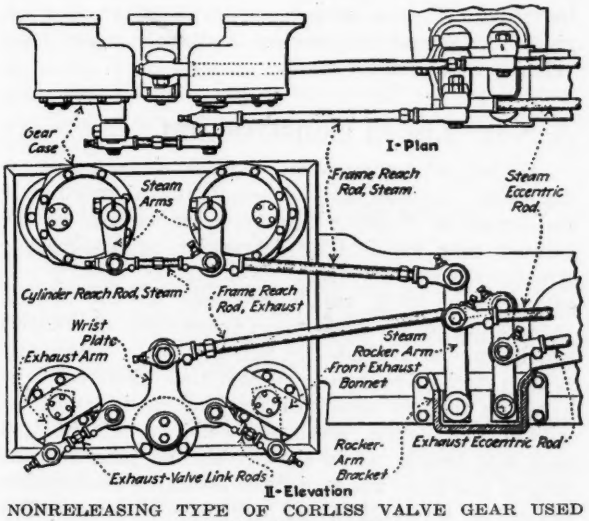
Questions and Answers

Setting Valves of a Nonreleasing Corliss Engine

WHAT IS the proper procedure for setting the valves of a four-valve nonreleasing Corliss engine?

M. J. M.

A. In setting the valves of an engine of this type, which is illustrated in the accompanying figure, the eccentric rod is adjusted so that the rocker arm travels equal distances on each side of the vertical position.



NONRELEASING TYPE OF CORLISS VALVE GEAR USED WITH BALL ENGINE

The eccentric is then blocked up with the governor weight arm in its extreme outer position. In this position the center of the eccentric is in line with the centers of the suspension pin and of the shaft. Next, the engine is turned over until the steam valve at the crank end, moves its maximum distance toward its open position. If the valve does not come within $\frac{1}{32}$ to $\frac{1}{16}$ in. of uncovering the port, the reach rod connecting the rocker arm to the steam arm should be adjusted until the valve is in the position stated.

When the engine is turned over until the head-end valve is moved towards its open position, the lap at the end of the valve travel should be $\frac{1}{16}$ to $\frac{1}{32}$ in. If it is not, the cylinder reach rod which connects the two steam arms, should be adjusted. If this is done, the engine will not take steam when the speed throws the governor weight to its extreme position. In order to adjust the point of cutoff accurately for the two ends it is necessary to take indicator cards. The cutoff should be adjusted by means of an indicator so that it is practically the same at both ends. As there is considerable wiredrawing at no load, this should be taken into account. The pressure before cutoff should be about half the pressure at the throttle.

In setting the exhaust valve, the link connecting the two exhaust valve arms should be equal in length to the distance between the valve centers, for cylinder diameters less than 19 in. Where the cylinder is more than 19 in. diameter, an exhaust wristplate is used and the exhaust valve link should be adjusted so that, when the wristplate is turned to bring the wristplate pin and the two link pins in a straight line, the exhaust valves should cover the ports with equal lap on both edges of the ports.

When the engine is turned over, the two exhaust valves should open equally. If not, adjust the length of the valve rod until both port openings are equal. The exhaust eccentric on the shaft is now moved so as to cause compression to begin at the desired point. This should be such that the compression pressure will rise to about half the throttle pressure. Head-end compression should be a little greater than that at the crank end. The correct amount is the least compression with which the engine will run smoothly.

Power Required by Brine Circulating Pump

CENTRAL BRINE COOLING having a total refrigeration load of 25 t. is installed in a building containing markets. Brine is cooled in a shell and tube type brine cooler, entering at 8 deg. and leaving at 4 deg. Specific gravity of calcium brine is 1.218. How many horsepower are required to operate the brine circulating pump, which has an overall efficiency of 80 per cent and which pumps against a total head of 20 lb.? E. J. S.

A. 25 t. of refrigeration is required, therefore $25 \times 200 = 5000$ B.t.u. per min. required. Calcium chloride brine of specific gravity of 1.218 has a specific heat of 0.7025 per lb. If the brine picks up 4 B.t.u. each time it goes through the cooler, it will carry 4×0.7025, or 2.81 B.t.u. per lb. pumped.

Since it is necessary to carry 5000 B.t.u. per min., it will require $5000 \div 2.81 = 1780$ lb. of calcium chloride to be circulated per min. Each pound must be pumped against a 20-lb. head. This will require 1780×20, or 35,600 ft. lb. of work per min. The pump only works at 80 per cent efficiency. This will require an expenditure of $35{,}600 \div 80 = 44{,}600$ ft.-lb. of work per min.; 33,000 ft.-lb. per min. equals one hp. The horsepower required will be then $44{,}600 \div 33{,}000 = 1.35$ hp.

WHEN COAL COKES badly, the fuel bed should be broken up occasionally with a slice bar to permit the free passage of air.

Editorial Comment

Business Ahead

Spite of the upset in the stock market, which now seems to have settled to an even course, the outlook for business ahead seems good. In a survey of American industry by the editors of business papers in all fields, it was found that optimism prevails. Some industries engaged in supplying commodities of the luxury class will have, at least temporarily a recession from their highest activity, but more capital available and at lower rates will encourage expansion in production of essentials such as industrial buildings, private homes and public works.

No industry, even in the luxury field has been crippled. Purchasing power of the public and their will to purchase may be somewhat curtailed for a time but, as there has been no overproduction of commodities or inflation of prices and employment is being maintained, demand is likely to increase after a brief period of slackening.

In the power field, 3.9 per cent more electrical energy was used in October, 1929, than in October, 1928; plant construction was some four per cent less than last year but that has been true since May, so cannot be attributed to the stock market condition.

On all sides are to be found confidence in the future. The "wise lambs" who thought they could outguess the "Wolves of Wall Street" have learned another lesson. But the general feeling seems to be that the next thing is to work harder, put all energy into production and sales to recoup losses and—in future to buy sound securities on the basis of income producing investments.

Budgeting Plant Services

At about the beginning of their fiscal year, the boards of directors of nearly all business concerns meet and decide how their funds shall be spent, how much money each department shall be allowed to carry on its work, what improvements shall be made and how much money shall be set aside for contingencies. This same idea might well be applied in the industrial power plant to proportion the services rendered by the plant among the different departments.

As a rule, the superintendents and foremen in the various departments of a factory are prone to consider that such conveniences as hot and cold water, steam, compressed air, electric power and light are theirs to use without restriction, provided, of course, they are not wasted. For this reason, it has become necessary for the power engineer to interest himself in the processes wherein his services play an important part and to determine how he can proportion his load so as to meet the essential requirements of all departments with as little total loss as possible.

To accomplish this, the heat balance diagram, which has come to be universally used in central station power plants, is being applied in industrial plants. Each type of plant represents an entirely different problem but, by studying the heat flow, determining the requirements of various departments, putting intermittent processes on definite schedule and reclaiming, as far as possible, all rejected heat, the engineer can put his plant on an efficient basis. With the aid of recording and integrating instruments, each department can be charged with the services it uses and credited with the reclaimed heat which has been returned.

This budgeting of services or balancing of heat and power requirements is progressing in a number of industries, the results of such practice being pointed out in this issue by several engineers prominent in different industries. Here is an opportunity for the power engineer to extend his services and make them more valuable to his employer.

A New Era in Construction

Methods of testing welds in place, without destroying them, discussed at the recent annual meeting of the American Welding Society, seem to open up an entirely new era in the fabrication of engineering structures made of metal. Welding, by electric arc, oxy-acetylene torch, atomic hydrogen process, thermit process, has within a few years become one of the most widely applied methods for joining metals, principally steel to steel. Yet during all that time, there has been a feeling that we were sometimes taking long chances with it. Of course, specimens could be cut out of a weld and tested, yet in the process the joint was destroyed and there was no definite assurance that another section of the weld would not show a defect. The entire piece could be tested to destruction, assuming that, if the weld did not fail before the metal, then welds made by the same welder on metal of the same characteristics on the same job, would be successful. Everything depended on the skill of the welder and the thoroughness with which he was checked and supervised. In the face of this uncertainty, the number of successful welding jobs that were performed was astoundingly high. Even though a minor part of a welded job might prove defective, seldom did a whole job prove a failure. Hydrostatic tests could usually be made of piping and pressure vessels and, if the job withstood these tests, that was certainly safe enough. In short, even though there was no absolutely definite test for a weld without destroying it, the work went on with a great deal of courage, considerable luck and practically no serious failures causing damage to life and property. The few failures that occurred were explained by lack of suitable precautions in welding.

Now, however, indications are that definite, dependable tests can be made right on the job and within a few moments after the weld is finished. Use of the stethoscope, followed by detailed examination of any

suspected spots by the X-rays, was described at the American Welding Society meeting by Messrs. Kinzel, Burgess and Lytle. Another method, using electricity, has been developed by Dr. Elmer A. Sperry. This is now in use testing rails in place. The apparatus not only records on a chart the presence of a flaw but also squirts a spot of white paint on the rail where the discontinuity occurs. The electrical method has also been used with great success for examining joints in drums, piping and other welded work.

The field opened up by these methods of inspection in place appears almost limitless. Design of all types of joints will doubtless undergo further rapid and far-reaching changes to meet the new conditions. For a long time, we have been using electric and gas welding as a fabrication method but always with that little gnawing feeling that, if the welder himself were not always as conscientious as we hoped, failure might result. It speaks volumes for the integrity of the man with the electrode or the torch that so much success has been attained. Now it appears that we have methods which will prove beyond question how good the operator actually is and which will remove the uncertainty of the human element in welding. The impetus that this will give to the use of welding in shop and field means nothing less than a new era in metal fabrication.

Sometimes a Study of the Other Fellow's Problem Helps

Inbreeding of industry, developing with it a natural tendency to deepen the ruts of routine is not commonly accepted as a healthy condition or one leading to improved methods of production.

As a rule, men in the plant resent the implication that someone less steeped in trade lore can help them and with such an attitude it is no wonder that each industry has grown up inside a hedge through which it is just as difficult for those inside to see out as it is for those on the outside to see in. True, many advances have been made through intensive study by those in direct charge but at the same time many of the major improvements have been made by outsiders, men who have had experience in other industries.

In the modern industrial establishment, the generation and utilization of electric power and steam is of major importance although not necessarily a major factor in the cost of the finished product. As such, it is the function of the power engineer to devise more direct and effective application of the commodities he handles, heat and power.

Good power engineers will be familiar with developments in their own industry and the application of their output to the particular industry which they serve. Few of them realize the importance of making themselves familiar with the problem of other industries. At the present time paper mills and steel mills are particularly active in power plant development work and an inspection trip through practically any new power plant built for one of these industries and a study of their demands will prove of interest and value to engineers from other industries.

Paper mill electric drive, one of the most delicate and exacting services in industry, has been developed and is in use in many new plants; steel mill electric drive, one of the hardest and most severe services, has been successfully solved and is being installed as fast as equipment can be supplied; glass plants are making extensive use of electrically heated lehrs; paper mills are successfully adapting steam accumulators while steel mills and chemical plants are utilizing high-pressure evaporators maintaining practically a closed system within the boiler and steam system proper.

By carefully following advances in his own industry, an engineer keeps abreast of the procession but only by a contemporary study of other industries does he place himself in the position of leader. A study of a steel mill power plant may be of more value to a paper mill engineer than a similar study of a paper mill power plant. The latter gives him information with which he, if he is a wide-awake engineer, already knows, while the former gives him new ideas and may be the means of important improvements.

An intensive study is necessary for improvements in details but often a comprehensive view of the whole or a comparison with something somewhat dissimilar leads to short cuts of much greater importance than detail. Many valuable improvements in industry come from ideas and methods developed originally for an entirely different purpose.

When Nature Runs Wild, Interconnection Smooths the Path Back to Normal

Evidences of the ability of the electrical industry to cope with emergencies appear from time to time but no better evidence than the recent catastrophe at Augusta, Ga., has yet been offered to show the value of interconnection and the well organized coöperation of operating companies and manufacturers.

During high water recently the levee and city-owned canal which supplied the many industries with hydraulic power was damaged. A similar experience just 21 yr. ago meant something over two months enforced idleness while the damage was repaired. Faced with another such calamity, the thousands of operators were despondent and the city in despair.

Times have changed, however, and this time carloads of motors, shipped two or three days after the washout was reported were installed and the mills operating a week later. Six of the largest industries were operating not more than ten days after the flood, while the nearby hydroelectric plant was still under water. Not only were these mills all changed over from mechanical to electrical drive but provision was made to supply power from different portions of the state.

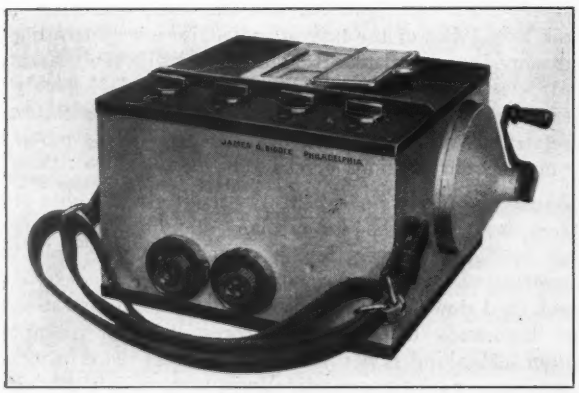
Instead of weeks of idleness without street lights or street cars, with the steam plant standby furnishing only sufficient power for household lighting, plant operation was back to normal in a week after the excitement died down and a crisis meaning actual privation for thousands of households forestalled by prompt action. Mankind is not yet able to control the elements but power and interconnection loom large in minimizing the effects of such catastrophies.

Power Plant Engineering Developments and News

New "Megger" Instrument Covers Wide Range of Uses

FOR MEASURING resistance from 0.01 ohm up to 100 megohms (100,000,000 ohms), James G. Biddle, 1211 Arch St., Philadelphia, is offering a new "Megger" instrument called the "Bridge-Meg" Resistance Tester. This instrument combines in one unit facilities for making Wheatstone bridge measurements of conductor resistance at 250 v. and also "Megger" tests of insulation resistance at 500 v. It weighs 12¾ lb., and measures 7 by 8¾ by 12 in. It includes necessary dial resistances for "bridge" tests, a direct-reading ohmmeter for "Megger" tests, and a 500-v. d.c. constant-pressure hand generator for current supply.

The range of measurement covered by the "Bridge" is from 0.01 ohm up to 999,900 ohms and the "Meg" (or "Megger") range is from 10,000 ohms up to 100 megohms. The "Meg" portion of the set is similar to Biddle's "Meg" and "Super-Meg" Insulation Testers —direct reading by means of a pointer over a scale when connections are made and the hand-crank is turned. The "bridge" arrangement has four dials of nine coils each in the resistance arm, giving a total of 9999 ohms. A five-position ratio dial ($\div 100 \div 10 \times 1 \times 10$ and $\times 100$) gives the added breadth of range down to 0.01 ohm and up to 999,900 ohms. As a "bridge" it is operated in the same way as an ordinary Wheatstone bridge set except that instead of employing a battery, current at 250 v. is supplied by the hand generator, and the ohmmeter is used as a galvanometer for balancing. Balance can be obtained quite rapidly by manipulating the resistance and ratio dials while the hand-crank is being turned.



BRIDGE-MEG RESISTANCE TESTER

There are only two binding posts, which are located on the side of the instrument opposite the hand crank. The change from "Bridge" to "Meg" and vice versa is made merely by turning a two-position dial. This and the ratio dial are shown near the base of the instrument in the picture. The "bridge" rheostat dial positions are shown by numbers on disks which appear through small windows next to each dial. The case is of cast aluminum with bakelite top and base. A metal lid covers the "Meg" scale. A leather strap is provided for carrying.

An important feature of the hand generator is a slip-clutch arrangement by which a constant potential is delivered when the hand-crank is turned at or above its rated speed of about 160 r.p.m. This makes it possible to use the instrument as a "bridge" under all conditions, including tests where a considerable amount of self induction is present—such as in large coils,—and also as a "Meg" for insulation resistance tests under all conditions including large apparatus and long cables where there is usually a considerable amount of electrostatic capacity.

The "Bridge-Meg" is designed and intended for practical everyday use by any one who needs to make rapid and accurate tests of resistance. It is rugged and practically fool-proof.

Marley Superheaters for H.R.T. Boilers

SUPERHEATERS for horizontal return tubular boilers, made by The Marley Co., Kansas City, Mo., were described on page 556 of the May 1, 1926 issue of Power Plant Engineering. Several changes in design of these to improve their effectiveness have recently been announced.

On both Type B and Type C superheaters, the cast-

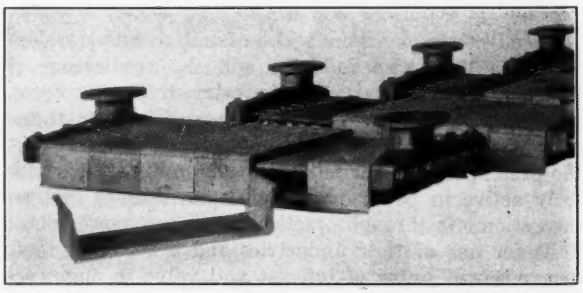


FIG. 1. COVER PLATES ARE NOW SUPPORTED INDEPENDENT OF TUBES

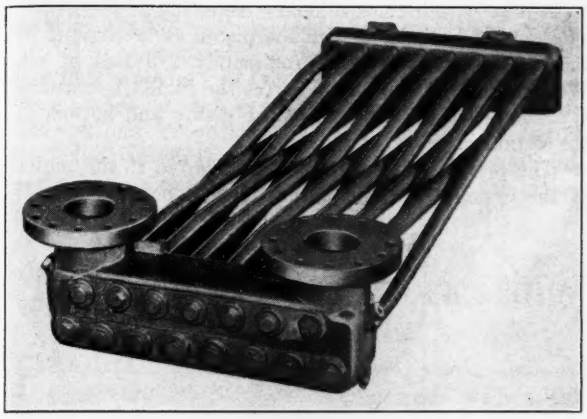


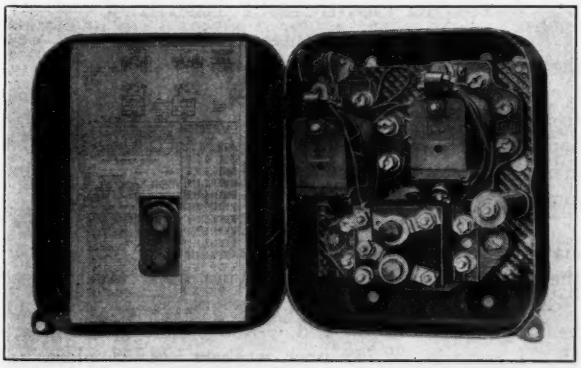
FIG. 2. NEW DESIGN OF TYPE B UNIT WITH CROSSED TUBES

iron cover plates have been rearranged so that they are supported independent of the superheater tubes instead of resting on the tubes. The new construction is shown in Fig. 1.

Principal change in the Type B superheater is in tube arrangement. Figure 2 shows this new design. The former Type B unit had two rows of straight tubes connected through a return casting at one end and through separate header castings at the opposite end. In the new unit, as shown, the tubes are criss-crossed in order to equalize changes due to temperature variations. Also, the tubes are rolled into a single common header instead of into two separate headers. This is done to make the unit more compact and to assure more accurate assembling and machining. Another object of crossing the tubes as shown is to give all the tubes equal exposure to the hot gases passing through the superheater.

Across-the Line Direct-Current Starter

AUTOMATIC, across-the-line starter, for general applications of direct-current motors up to 2 hp., 115 or 230 v., is announced by Cutler-Hammer, Inc., 191 12th St., Milwaukee, Wisc. Features incorporated in this new design are stated to be: small size, low cost, double-line break, thermal overload protection, low voltage protection, silver contacts, and completely enclosed structure. Two magnetic contactors, one in each side of the line, are used to connect the motor directly across the line on starting and to provide a double line break. The contactors, designed especially for direct current service, have renewable silver contacts and a heavy stamped frame.



ACROSS-THE-LINE D.C. STARTER WITH OVERLOAD RELAY

Thermal overload relays are the same as those used in this company's alternating current across-the-line starters for small motors. They are of the fusible alloy type and can be adapted to any size motor by simply changing heater coils. When tripped by an overload, the relays are reset by pushing a button in the cover.

Each starter is furnished with a pushbutton master switch providing three-wire control. This switch can be mounted in the cover or separately. These starters are also made without the thermal overload relays, for applications where overload protection is not required.

Type U Underfeed Stoker

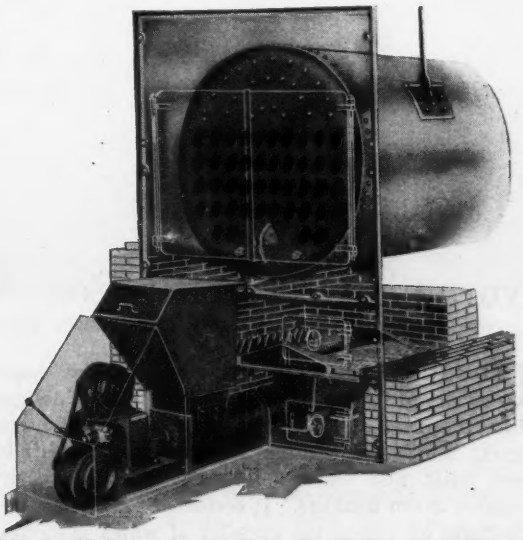
UNDERFEED STOKER known as the Type U has recently been placed on the market by the Marion Machine, Foundry & Supply Co. of Marion, Ind. It is intended for use in steam power plants with boiler ratings up to 200 hp. The component parts consist of retort, tuyeres, dump grates, conveyor screw, hopper, transmission, fan motor, machinery casing and control.

From the hopper, the coal is automatically conveyed by a revolving spiral to the retort inside the furnace where it is fed from underneath, upward into the fire area. As the fuel rises, it spreads evenly over the tuyere openings, through which air is supplied from the blower.

Air supply is regulated by damper and the fuel transmission has three speeds to make it easy to regulate the fire to the load requirements.

As the fuel is fed upwards and burned, it spreads outward and deposits ash and clinker on side grate bars, whence they are periodically dumped into the ash pit. The grate bars have a cutting action to crush the clinker into small pieces.

Transmission and fan are electrically driven, the motor setting directly above the transmission gears, to



TYPE U UNDERFEED STOKER SHOWING BLOWER AND DRIVING MECHANISM

use a minimum of floor space. Motor, transmission and fan are equipped with roller and ball bearings. All gears are cut, hardened and heat treated. The spiral is made of steel. All machinery is covered with a steel case. An automatic regulator and switch are furnished with each stoker.

Power Digging

WHERE TRENCHES, pockets or tunnels are to be excavated in stiff clay, the power tool replaces pick and shovel to the comfort of workers and expedition of the work. The Clay Spader, M-1, improved by Sullivan Machinery Co. is designed for such work,

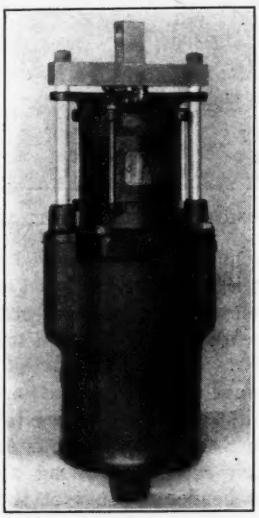
CLAY SPADER IN NARROW TRENCH DIGGING

utilizing compressed air as driving power. It consists of a light air hammer, equipped with a pick, a chisel or a narrow spade and with control valve for air. Tools are held to the hammer cylinder by a single-bolt retainer, the tool being forced into the work by the hammer blow. For narrow trenches such as for pipe or conduit, for caisson excavation and for underground work in hard clay, digging may be reduced to a minimum. Use for a narrow trench is illustrated. Weight is 25½ lb., length of hammer 19½ in. and with standard spade 33 in. Longer shank tools can be used for deep trenches.

Hydraulic Operator, a Control Device

HYDRAULIC OPERATOR, an industrial control developed by the General Electric Co., is designed to take the place of large alternating- or direct-current magnets and solenoids and to replace air cylinders where quiet and smooth upward thrust is desired through a given distance. It consists of a motor-driven centrifugal oil pump, the impeller of which is mounted in a piston and driven by a spline shaft. This arrangement is to permit the stationary mounting of the motor. The normal position is with the piston at the bottom of the cylinder, which is approximately 2/3 full of oil. When energized, the motor drives the impeller, creating a pressure between bottom of the piston and bottom of the cylinder.

The piston is cast so that the oil is fed to the center of the impeller from both the top and bottom. The oil



HYDRAULIC OPERATOR

is forced from the end of the impeller blades through ports to the space below the piston. The pressure tends to move the piston upwards and it will travel the full length of the cylinder, provided the load on the ends of the push rod is not too great.

The operators are rated on the stalled thrust basis; that is, the number of pounds they will balance when the motor is running at full speed. The three standard sizes give 200, 300 and 600 lb. push. The speed of operating is slower than that of a solenoid but is relatively fast. The motors used are small, ¼ to ½ hp., therefore they come up to speed in approximately 0.1 sec. The time required to raise the piston will depend upon the diameter and speed of the impeller, the diameter and length of the cylinder and the load to be lifted.

The device can be applied to brakes, clutches, door and window openers, spot welders, pumps and other places now filled by solenoids and air cylinders.

Rapid Condenser Relining

WHAT PROBABLY constitutes a record for speed was the complete relining of the 40,000-sq. ft. condenser of the Sherman Creek generating station by a crew of men recruited from the pipe fitters, machinists, ash handlers, boiler cleaners and engine room force of the plant. The men had just nine days and 15 hr. to do the work in, and they finished the job in nine days and 7 hr.

The magnitude of the achievement will be appreciated when it is considered that the job consisted of the following operations: Removing 5200 wood plugs, 16,274 ferrules, 32,748 fiber washers, 32,748 pieces of packing, 32,748 tubes, and cleaning and reaming out 16,274 ferrules, 32,748 fiber washers, 32,748 pieces of these parts were replaced in addition to the ferrules

being heated and tightened while hot. This makes a total of 258,997 separate operations, done in the period of 223 hr. and 25 min. After the tubes were installed, two fiber washers and two pieces of corset lace packing were placed on each end of each tube and the ferrules screwed on. The whole condenser was then heated up until the paraffin in the packing was soft and while hot, every ferrule was tightened. On account of the intense heat, a man could work only 10 min. at a time.

Pneuma-Lectric Lubricating System

PNEUMA-LECTRIC Lubricating System, designed for feeding grease through one or more headers with connecting lines to practically any number of bearings at varying distances up to about 300 ft. and equipped for complete automatic operation with intermittent feed adjustable to the requirements of the lubricated unit,

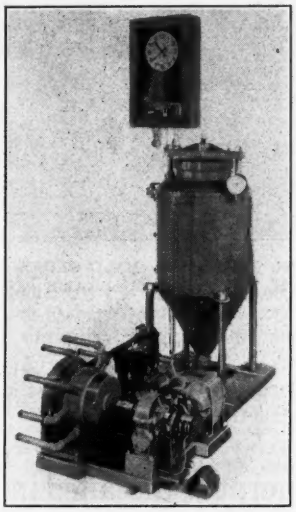


FIG. 1. PNEUMA-LECTRIC UNIT WITH MOTOR DRIVEN ROTARY DISTRIBUTOR AND TIMING CLOCK

has recently been announced. It is designed so that time at which grease is fed may be varied from once in 5 min. to once in 24 hr.

In this machine, Fig. 1, a grease tank is mounted on a common base with an automatically-controlled, motor-driven air compressor. This compressor is regulated to maintain 170 to 210 lb. pressure in the tank above the grease, which discharges from the conical tank bottom to the rotary distributor, motor-driven through a reduction unit.

Operation of the distributor motor is controlled by an electric clock, which may be set to any predetermined time period. When the time period has been reached, a relay, actuated by the clock, starts the motor. This operates the distributor, which supplies a charge of grease to each bearing consecutively; the distributor operates for about 12 sec., until the clock breaks the contact.

To prevent the distributor from stopping on an open port, a drum control switch keeps the distributor moving until the safety zone is reached. Here a shunt electric brake stops the motor.

The rotary distributor, Fig. 2, is made in two sizes, No. 2 with a 2-in. rotor and 8 outlets and No. 8 with an 8-in. rotor and 24 outlets. Grease enters the hollow rotor and, as the master port registers with an outlet port, the grease passes to a line leading to a bearing. Pilot lamps at convenient points in the circuit show when the unit is operating.

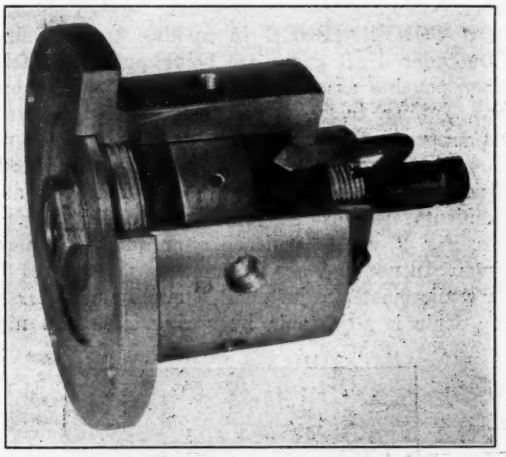


FIG. 2. CUT-AWAY VIEW OF DISTRIBUTOR

This new lubricating system is a product of the Keystone Lubricating Co., Philadelphia, Pa. Although the various parts of the system are shown together in Fig. 1, their location can be varied to meet the needs of each case.

Kant Slip Pliers

PRINCIPLES of the cam, the fulcrum and the wedge have been employed in the design of the Kant Slip plier, shown herewith, to give it a powerful, parallel grip, and to permit it to perform work that has heretofore required wrenches of various sizes and type.

PLIER DESIGNED SO THAT LOAD COMES ON FULCRUM INSTEAD OF PIN

The cam is arranged to slide the fulcrum to its correct position, irrespective of the load. It is designed so that load comes on the fulcrum and not on the pin; the latter is solely to hold the two members together. The sliding actions of both the cam and the fulcrum are intended to wedge the work between the jaws. There is no screw adjustment.

Kant Slip is a drop-forged tool of a special alloy chrome vanadium steel, hardened throughout. Teeth are accurately machined, it is stated; handles are shaped to fit the hand. It is manufactured by Kant Slip Plier & Tool Co., 6036 Wentworth Ave., Chicago, Ill.

Portable Draft Gages

FOR CONVENIENCE in making tests, a line of Defender draft gages are being put up in folding leather pouches as shown in Fig. 1, in sets of one to four. Tubing, tools, screws, micrometer brackets and other accessories are packed in a folding pouch which fits inside the main pouch. The gages and can of oil are held in the pocket of the main pouch, a snug fit and of convenient form for the pocket or traveling bag. The gages, Fig. 2, are of polished aluminum with nickeled fittings. In use they are mounted by screw holes 3 and 6, or a micrometer adjustment, 8 may be used for leveling. Scale is adjustable by spring clips and nipples

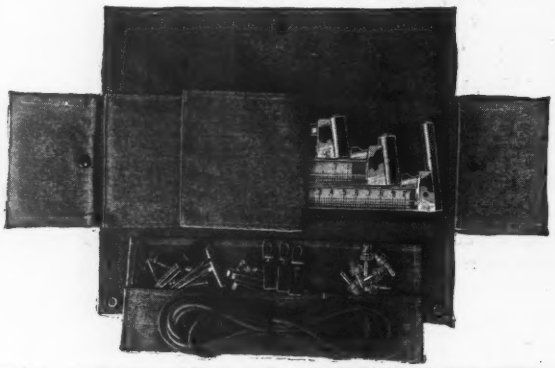


FIG. 1. THREE GAGES AND ACCESSORIES FIT INTO A CONVENIENT POUCH

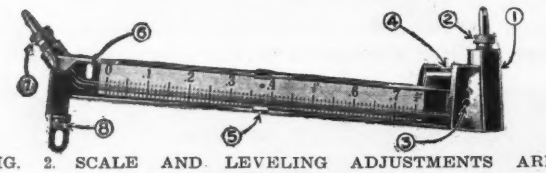


FIG. 2. SCALE AND LEVELING ADJUSTMENTS ARE PROVIDED

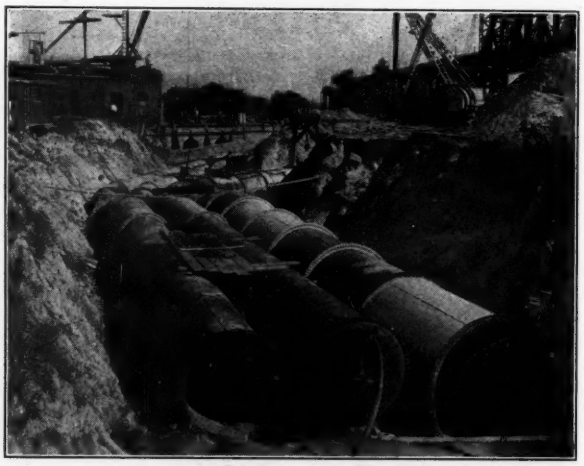
2 and 7 can be replaced by ⅛-in. pipe plugs to retain the oil for carrying. For the set as shown, the gages are 5 in., 7½ in. and 10 in. long to read to ½ in. of draft, ¾ in. and 2 in. respectively.

Large Intake Pipe Fabricated by Arc Welding

KANSAS CITY POWER & LIGHT CO., Kansas City, Mo., has just laid about 4000 ft. of water intake pipe from the Missouri River to its plant, which is shown during construction in the accompanying illustration. The pipe is partly 54 in. and partly 84 in. diameter, all made of ⅝-in. copper-bearing, mild-steel plate.

Longitudinal seams and flanges were all arc welded with a new electrode recently developed by the Fusion Welding Corp., Chicago. This mild steel electrode is called Yellow Jacket and is designed to produce 100 per cent joint efficiency in heavy mild steel arc welding. Plates are butted together without beveling and a bead run from each side. Because there is no bevel to be filled, so little filler material is required that high speed work is possible, it is claimed, even with manual welding.

Tests were made by Robert W. Hunt and Co. and it was found that the maximum joint efficiency using rivets was 86 per cent, while 100 per cent joint efficiency was obtained with the Yellow Jacket welds, all test pieces breaking outside of the weld and pulling a minimum of 60,000 lb. per square inch. The pipe was fabricated by the Kaw Steel Construction Co. of Kansas



VIEW OF 54-IN. AND 84-IN. MILD-STEEL-PLATE INTAKE PIPE, WITH ARC-WELDED SEAMS AND FLANGES

City. A somewhat special technique is required in using the new electrode and George A. Tabuas of the Reid Sales Corp. of Kansas City was the engineer in charge of instruction.

Giant Generator Installed in New York

IN THE EAST RIVER STATION, a 160,000-kw. generator of the single-shaft, single-unit type, costing $12,500,000, has just been placed in service. This unit and its accompanying steam driver, representing a 215,000-hp. turbo-generator outfit, is 60 per cent larger than the largest existing single generator in the country. It has a tandem-compound steam turbine directly connected by a single shaft to the single generator. The complete outfit weights 1200 t. without additional equipment of any sort. It is 87 ft. long, 24½ ft. wide and 21½ ft. high.

This unit was completely built and partly assembled at the General Electric plant in Schenectady, N. Y. On account of its huge size, it had to be largely knocked down for shipment and then reassembled at the East River plant. The two halves of the armature alone aggregated 500,000 lb. of steel, or some 300,000 separate pieces. The laminations were forced in place with a 1200-t. hydraulic press.

Three boilers which will furnish steam for the new unit are of the Double Ladd type, built by the Combustion Engineering Corp. These boilers, eight stories high, burn pulverized coal, producing flame sprays 50 ft. long, at temperature of 2500 deg. F., generating steam at 725 deg. and at a pressure of 425 lb. per square

inch. Each boiler requires 80,000 lb. of coal an hour. A new condenser manufactured by the Ingersoll-Rand Co. converts the steam back into water to be used over again. This condenser required 20 cars to accommodate its components, when shipped in knocked-down form.

News Notes

To MEET the increase in demand during the current year for its products, Sullivan Machinery Co. has recently completed an addition to its Michigan City plant, also added to its equipment at Michigan City and Claremont, N. H., and has placed orders for additional machine tools to secure a larger volume of production.

ARRANGEMENTS have been made whereby Thermix air preheaters for boiler service will be sold exclusively by the Babcock & Wilcox Co., New York. The Prat-Daniel Corp. will continue to furnish Thermix air heaters for other applications.

HENRY AYLETT COLES, Atlanta district manager of the Westinghouse Electric & Manufacturing Co., died recently in New Orleans, La., of heart failure. A veteran in the Westinghouse service, he had joined the company while its plant was located in Garrison Alley, Pittsburgh. He was born in Tallwood, Albemarle County, Va., August 17, 1870. Following his graduation in 1891 at the University of Virginia, Mr. Coles spent six months operating an electric light plant in Charlottesville, Va., then entered the employ of the Edison General Electric Co. Leaving there, he entered the Westinghouse service.

SELF-LUBRICATING BRONZE BEARING has just been announced by Johnson Bronze Co., New Castle, Pa. According to P. J. Flaherty, president and general manager of the company, the new bearing is so designed to provide a uniform area of bearing surface on the pressure line and to insure an efficient distribution of lubricating compound. The compound used is also a Johnson Bronze development. New method is used to effect indentations in the metal and to place them at an angle of 30 degrees.

DURING THE WEEK of Mar. 3, 1930, the National Industrial Equipment Exposition will be held in Stevens Hotel, Chicago, where water, steam, compressed air and electric current will be available for operation of exhibits. Six divisions will cover: Industrial plant construction materials, materials handling, power transmission, factory operation, management, industrial research. At the same time will be held a National Management Congress and a meeting on Materials Handling to discuss problems in these fields, looking to more effective operation of factories and distribution to reduce costs of products. Diversification, attractive arrangement and the use of color, with operating models will lend interest to the exhibits and exemplify applications of equipment to production processes. The Exposition is in charge of G. E. Phisterer, 308 W. Washington St., Chicago, Ill., from whom details may be obtained.

GENERAL REFRACTORIES Co., Philadelphia, Pa., has announced the Harris Pump and Supply Co., 319-21 First Ave., Pittsburgh, Pa., as its dealer representatives in the Pittsburgh district.

ALLIS-CHALMERS MFG. Co., Milwaukee, Wisc., has appointed the T. B. Wood's Sons Co., Chambersburg, Penn., as special distributors.

CHAIN BELT Co., Milwaukee, Wisc., announces the distribution of its equipment through five new distributors in the Southeast. The Bailey-Lebby Co. of Charleston, S. C., The Georgia Supply Co. of Savannah, Ga., and Jacksonville, Fla., Harry P. Leu Co. of Orlando, Fla., and the J. M. Tull Rubber and Supply Co. of Atlanta, Ga., are the new distributors.

MERGER has just been effected by the Oster Manufacturing Co. of Cleveland, Ohio, and the Williams Tool Corp. of Erie, Pa. The Oster Manufacturing Co. was founded in 1893 by Herman W. Oster and Russell B. Tewksbury. Its officers are R. B. Tewksbury, president, Roger Tewksbury, vice-president and treasurer, Arthur S. Gould, secretary. The Williams Tool Corp. was founded in 1901. Its officers were Horace W. Davis, president, E. P. Poole, vice-president, J. E. Humble, secretary and treasurer. Through the merger, Mr. Davis has been succeeded as president by Roger Tewksbury.

M. G. HARBULA, consulting engineer specializing in air conditioning, has moved his office to 1775 Broadway, New York City.

OCTOBER SALES of mechanical stokers, as reported to the Department of Commerce by the 10 leading manufacturers in the industry, totaled 178 with 56,108 hp., as compared with 155 of 45,685 hp. in September and 100 of 27,219 hp. in October, 1928.

Catalog Notes

ENGINEERING SPECIALTIES of the Curtis line are described and illustrated in Catalogs No. 60 and No. 60A issued by Julian d'Este Co., 6 Spice St., Charleston Dist., Boston, Mass. Pressure regulators of all types and for all purposes, temperature regulators, damper regulators, relief valves and traps of bucket and return types are included in the line.

"STEAM PRESSURES for Industrial Plants" is the title of a pamphlet by W. A. Shoudy, issued by Combustion Engineering Co., 200 Madison Ave., New York City. It deals with the trend toward higher steam pressure and possibilities in adopting a higher pressure cycle.

"WHY YOU SHOULD USE Flow Meters" is the title of an interesting booklet showing how meters may be used to check fuel and steam wastes and illustrating application in power and industrial plants. It is issued by The Brown Instrument Co., 4491 Wayne Ave., Philadelphia, Pa.

PRESENT TRENDS IN DUST RECOVERY are discussed in Bulletin No. 3 A, just issued by the Dust Recovering & Conveying Co., Harvard Ave. and East 116th St., Cleveland, Ohio.

FLEXIBLE COUPLINGS are completely illustrated and described in detail in a 36-page handbook just issued by Poole Engineering & Machine Co., Baltimore, Md.

NICKEL CAST IRON, theory and practice, is the subject of a 24-page bulletin issued by the International Nickel Co., Inc., 67 Wall St., New York, containing 10 studies of this metal made on ten different products.

TECHNICAL BULLETIN describing the "battledeck floor" construction has just been issued by the American Institute of Steel Construction, Inc., 200 Madison Ave., New York City. This is a floor made of steel plates welded to I-beams. Appended to the description are allowable load tables figured for both web shear or flexure, whichever is least.

SPECIFICATION SHEETS for its 300-amp. welder in various types are being sent out by the Lincoln Electric Company of Cleveland, Ohio. These cover the stationary platform type for alternating and for direct current; also the portable truck type for both kinds of current and the gasoline and belt driven stable arc welder, all types being for current range from 90 to 375 amp.

OXWELDED PIPING is the title of a 24-page booklet containing helpful and instructive information on the installation of oxy-acetylene welded piping for industrial uses and also for the heating of domestic and industrial buildings, issued by the Linde Air Products Co., 30 East 42nd St., New York. The first section considers the uses of oxwelded piping for the transportation of oil, gas, chemicals, water, and other fluids, the second section piping for heating and heating systems. Another booklet on Airplane Fusilage Welding treats of airplane manufacture with a section on welding of Duralumin.

PLIBRICO JOINTLESS FIREBRICK Co., 1836 Kingsbury St., Chicago, Ill., is distributing sets of Ringlemann smoke charts free of charge to engineers, as a contribution in the interest of smoke abatement and increased fuel-utilizing efficiency. These charts enable an engineer to measure the percentage of density of the smoke issuing from a stack. Complete instructions for the use of the charts accompany them. A table showing the seven common causes of smoking and the 33 principal remedies is also included. together with some data on the designing of furnaces to reduce smoking. The charts are enclosed in a strong envelope. A request on business stationery will bring any engineer a set.

GRAPHIC SPEED records in the operation of steam and hydraulic turbines is discussed in Bulletin 929 issued by the Esterline-Angus Co., Indianapolis, Ind.

NEW READING-PRATT & CADY catalog No. 330 covers Pratt & Cady iron and bronze valves, and asbestos packed cocks and Reading cast steel valves and fittings. It includes information on: care and use of valves; floor stand and chain wheel applications; motor operator applications; drilling tables for iron, bronze, and steel flanges; and a general section of useful information for the engineer, steamfitter and plumber. Copies may be had by writing to the Reading Steel Casting Co., Inc., Bridgeport, Conn.

EVERYTHING FOR MINE AND INDUSTRIAL SAFETY is the title of General Catalog No. 4, a 160-page publication just issued by The Mine Safety Appliances Co., Braddock, Thomas and Meade Streets, Pittsburgh, Pa.

ATWOOD INTERLOCK NECKS, Line Welds and Welded Headers are described in Folder No. 102, just issued by Pittsburgh Valve, Foundry & Construction Co., Pittsburgh, Pa.

Heat Saving Number, January 1, 1930

HEAT DEVELOPMENT and its transformation into various utilizable forms with the least possible loss is the field of the power plant engineer and has been chosen as the subject for special treatment in the January 1, 1930 issue of Power Plant Engineering. Heat, the raw material of the industry, has as its source the fuel introduced into the furnaces of boilers or the cylinders of internal combustion engines so that the start in the process of heat manufacture and transformation must be made with the selection of fuel.

Kinds of fuel, their heat content, the cost of heat in each form and its availability for development will, therefore, be given consideration.

Choosing a fuel is interlocked with the method of burning and the furnace to be used. Certain losses are unavoidable such as those from heating of fuel and contained moisture, from dissociation of hydro-carbons, from heating combustion air. Methods of reducing these to a minimum will be the subject of the furnace section, which will consider the most economical way to develop the heat from the fuel and transfer it to the heat-carrying medium, whether air, gas or water.

Heat Transfer

Getting the heat from furnace gases into steam with least loss is the next problem. Some will get away in flue gases, but economizers and air preheaters come in to reduce that loss. Some will be radiated, which can be reduced by insulating coverings. The remainder should appear in the steam.

Where does the energy of steam go? All of it cannot be utilized to do useful work. But radiation losses can be minimized, heat units in exhaust or in condensate can be caught and returned to the energy system and efficiency of prime movers can be improved. Steam used for process work can be reduced by careful management, leaks can be stopped, blowdown loss can be minimized; all along the line that steam travels, the precious heat units can be saved and, the farther along we go, the more important it is to save them for their value is increased at each step in development, transfer and transformation.

Work Energy

In the prime mover, heat energy becomes transformed into work energy. During the process, heat may be lost by radiation or by friction of moving parts. The remainder goes out as work energy in belts, in streams of fluid or as electric current. There will be a return into heat from slipping of belts, friction of fluids in pipes and resistance of conductors to current flow and such heat will be lost by radiation unless it can be reclaimed to heat combustion air or feedwater. Such reclaiming is helpful, but of greater importance is the minimizing of the turning of work energy back into heat.

Saving in Heat Development

Starting with the fuel, low ash, low moisture, suitability to the furnace, proper operation of the furnace are essential and those matters with the methods of analyzing fuel, characteristics of coals, methods of firing including hand, stokers and pulverization will be treated. All points where heat saving can be effected will be carefully analyzed and the methods for making such savings studied.

Heat Transfer to Steam

The effectiveness of heat transfer between gases and boiler water depends on the condition of surfaces, difference of temperatures and free moving contact of gases and water over the surfaces to allow giving and taking of heat. The location of heating surface to give it greatest effect, methods and importance of keeping surfaces clean, arrangements to ensure good flow of gases and circulation of water will be fully discussed.

As already mentioned, at all points in a heat energy system radiation takes place. Reduction to a minimum is the object and insulation the answer. Insulation of furnaces, boilers, piping, heaters is essential and it is vital to know when saving of heat is balanced by cost of additional insulation. Air-cooled walls, water-walls, importance of dry steam and the saving of drip condensate are all here treated.

Work from Heat

Wheels to be turned. This is the object to be attained and at least heat expenditure. The effects of high pressure, low vacuum, bleeding for feedwater heating, reheating of intermediate steam, and finally the catching of heat which passes out in prime mover exhaust and returning it to the system or making it further useful are the subjects of study in this section to get the best heat cycle. Condensate and cooling water carry a lot of heat. How can it be captured and utilized? Feedwater has to be heated somehow. What method will utilize most heat otherwise wasted and give, on the whole, best heat economy? What treatment of feedwater will best aid steam making and reduce the cost of plant operation? These are questions of heat saving vs. the cost of making the saving.

Changed to mechanical or electrical energy, heat is used for doing the world's work. Wasting it is expensive. Losses from friction, inefficient loading of machines, leakage of compressed air, burning lights uselessly, all are forms of wasting high cost energy. Care of bearings, efficient loading, stopping leaks, shutting off idle machines and lights are matters of a good operating system and routine but can be the means of saving a lot.

Combustion Engines

This method of utilizing heat energy is growing in importance and will have its separate section devoted to the losses involved, how they may be reduced and how heat escaping in cooling water and exhaust gases may be recaptured and put to work. The heat that is transformed to mechanical energy is, of course, in the same class as if it were transformed through the medium of steam.